HOW TO "READ" FM TUNER SPECIFICATIONS

Popular Electronics

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE JANUARY 1975/75¢

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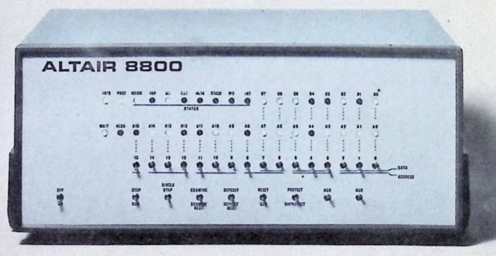
World's First Minicomputer Kit to Rival Commercial Models...

"ALTAIR 8800" SAVE OVER $1000



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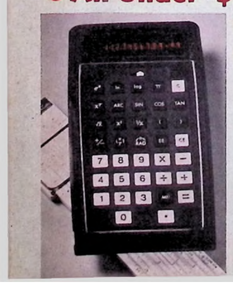
ALSO IN THIS ISSUE:

- An Under-$90 Scientific Calculator Project
- CCD's—TV Camera Tube Successor?
- Thyristor-Controlled Photoflashers



TEST REPORTS:

Technics 200 Speaker System
Pioneer RT-1011 Open-Reel Recorder
Tram Diamond-4
Edmund Scientifi
Hewlett-Packard

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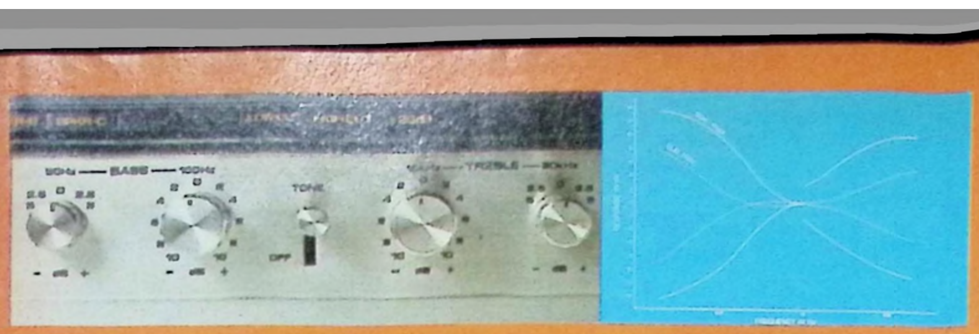

3,025 possible tonal compensations with unique twin stepped tone controls (SX-1010, SX-939)

Selector that permits FM recording while listening to records and vice versa. Up to three pairs of speakers may be connected to each model.

INPUTS	SX-1010	SX-939	SX-838
Tape monitor/4-ch. adaptor	3	2	2
Phono	2	2	2
Microphone	2	2	1
Auxiliary	1	1	1
Noise reduction	1	1	1
OUTPUTS			
Speakers	3	3	3
Tape Rec./4-ch. adaptor	3	2	2
Headsets	2	2	1
Noise reduction	1	1	1
4-channel MPX	1	1	1

Master control system capability

Pioneer's engineers have surpassed themselves with a combination of control features never before found in a single receiver. All three units include: pushbutton function selection with illuminated readouts on the ultra wide tuning dial, FM and audio muting, loudness contour, hi/low filters, dual tuning meters and a dial dimmer.

Never before used on a receiver are the twin stepped bass and treble tone controls found on the SX-1010 and SX-939. They offer over 3,000 tonal variations. A tone defeat switch provides flat response instantly throughout the audio spectrum. The SX-838 features switched turnover bass and treble controls for more precise tonal compensation for room acoustics and other program source characteristics.

In their respective price ranges, these are unquestionably the finest values in stereo receivers the world has ever known. Audition their uniqueness at your Pioneer dealer. SX-1010 — $699.95; SX-939 — $599.95, SX-838 — $499.95. Prices include walnut cabinets.

Also new and more moderately priced.

Pioneer's most complete and finest line of receivers ever, presents equally outstanding values starting at $239.95. Shown here are the SX-535 — $299.95, SX-636 — $349.95, SX-737 — $399.95. All with walnut cabinets.

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75 Oxford Drive, Moonachie,
New Jersey 07074
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90248/Midwest: 1500 Greenleaf,
Elk Grove Village, Ill. 60007/Canada:
S.H. Parker Co.

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SX-535

SX-636

SX-737

96
98
100
102
104
106
108
MHz
x10KHz
FM
AM
FM
PHONO-1
PHONO-2
MIC
AUX
MONO
LOUDNESS
TAPE
DUPLICATE
MONITOR
ADAPTOR
4CH
DOLBY NR
ON
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LEFT
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VOLUME
MIN
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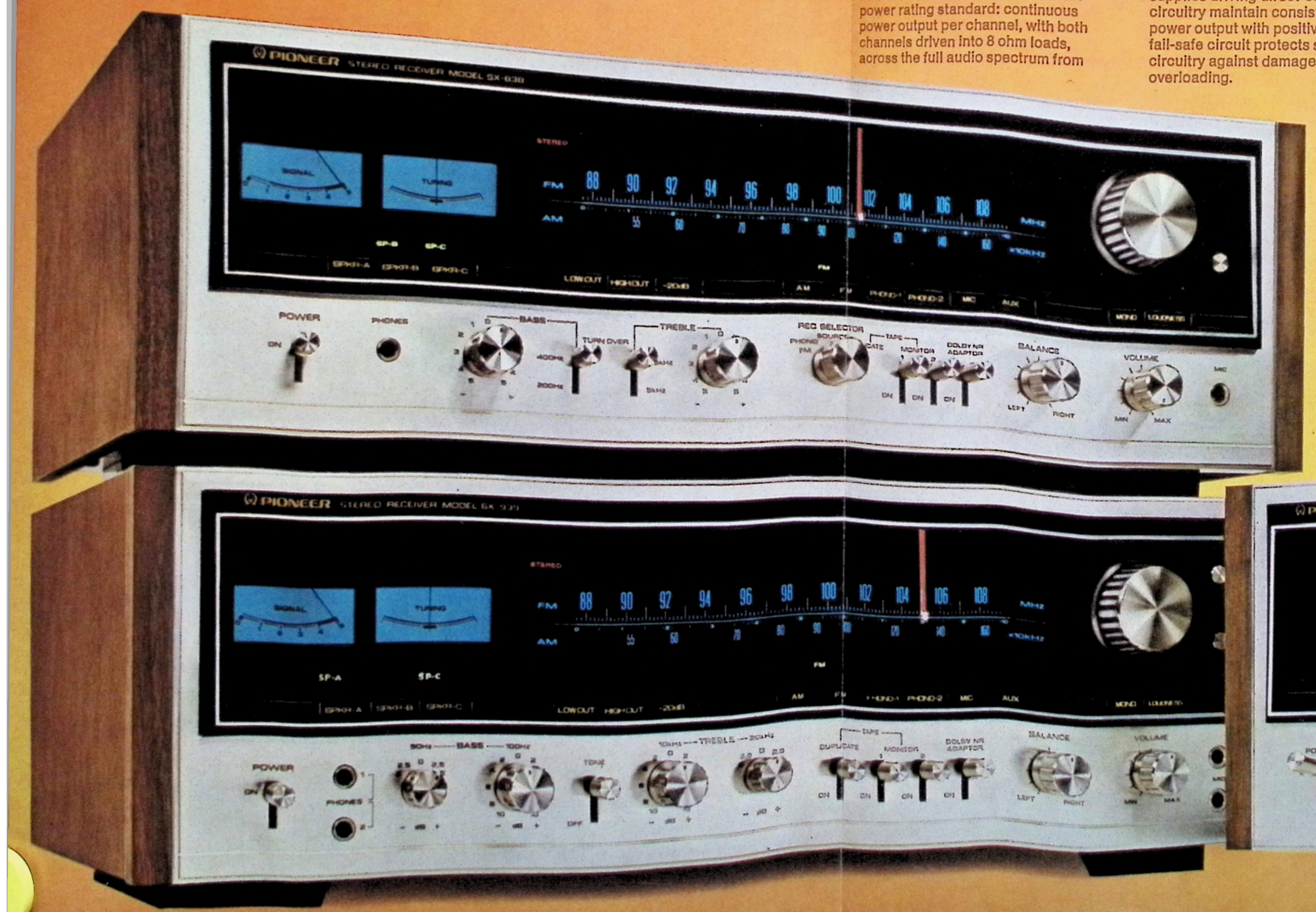
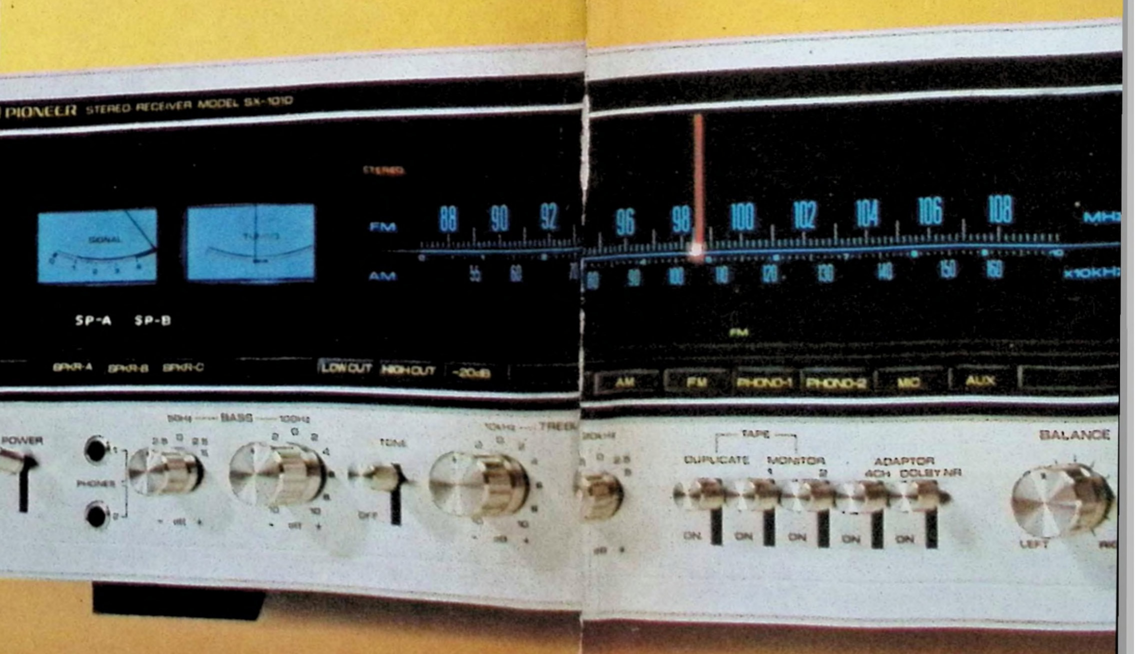

PIONEER STEREO RECEIVER MODEL SX-838
PIONEER STEREO RECEIVER MODEL SX-939



Pioneer believes that any objective comparison of quality/performance/price between our new SX-1010, SX-939 and SX-838 AM-FM stereo receivers and any other fine receivers will overwhelmingly indicate Pioneer's outstanding superiority and value.

The most powerful ever

Pioneer uses the most conservative power rating standard: continuous power output per channel, with both channels driven into 8 ohm loads, across the full audio spectrum from 20Hz to 20,000 Hz. Despite this conservatism, the SX-1010 far surpasses any unit ever produced with an unprecedented 100 + 100 watts RMS at incredibly low 0.1% distortion. Closely following are the SX-939 (70 + 70 watts RMS) and the SX-838 (50 + 50 watts RMS) both with less than 0.3% distortion. Dual power supplies driving direct-coupled circuitry maintain consistent high power output with positive stability. A fail-safe circuit protects speakers and circuitry against damage from overloading.

Outstanding specifications for flawless reception

FM reception poses no challenge to the exceptionally advanced circuitry of these fine instruments. Their FM tuner sections are designed with MOS FETs, ceramic filters and phase lock loop circuitry. The result is remarkable sensitivity, selectivity and capture ratio that brings in stations effortlessly, clearly and with maximum channel separation.

	SX-1010	SX-939	SX-838
FM Sensitivity (IHF) (the lower the better)	1.7uV	1.8uV	1.8uV
Selectivity (the higher the better)	90dB	80dB	80dB
Capture Ratio (the lower the better)	1dB	1dB	1dB
Signal/Noise Ratio (the higher the better)	72dB	70dB	70dB

Total versatility plus innovations

Only your listening interests limit the capabilities of these extraordinary receivers. They have terminals for every conceivable accommodation: records, tape, microphones, headsets — plus Dolby and 4-channel multiplex connectors. Completely unique on the SX-1010 and SX-939 is tape-to-tape duplication while listening simultaneously to another program source. The SX-838 innovates with its Recording

3,025 possible tonal compensations with unique twin stepp
(SX-1010, SX-939)

Selector that permits FM recording while listening to records and vice versa. Up to three pairs of speakers may be connected to each model.

INPUTS	SX-1010	SX-939	SX-838
Tape monitor/4-ch. adaptor	3	2	2
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Auxiliary	1	1	1
Noise reduction	1	1	1
OUTPUTS			
Speakers	3	3	3
Tape Rec./4-ch. adaptor	3	2	2
Headsets	2	2	1
Noise reduction	1	1	1
4-channel MPX	1	1	1

SX-535

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with ill
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filters,
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and SX
tonal v
switch
instant
spectru

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JANUARY 1975 VOLUME 7, NUMBER 1

Popular Electronics®

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Editorial

THE HOME COMPUTER IS HERE!

For many years, we've been reading and hearing about how computers will one day be a household item. Therefore, we're especially proud to present in this issue the first *commercial type* of minicomputer project ever published that's priced within reach of many households—the *Altair 8800*, with an under-$400 complete kit cost, including cabinet.

To give you some insight to our editorial goal for this momentous project, we were determined *not* to present a digital computer demonstrator with blinking LED's that would simply be fun to build and watch, but suffer from limited usefulness. High chip costs would have made this a most expensive toy. What we wanted for our readers was a state-of-the-art minicomputer whose capabilities would match those of currently available units at a mere fraction of the cost.

After turning down three computer project proposals that did not meet these requirements, the breakthrough was made possible with the availability of the Intel 8080 n-channel CPU (central processor unit)—the highest-performance, single-chip processor available at this time. As a result, *Altair 8800* offers up to 65,000 words of memory, 256 inputs and outputs simultaneously, buss line expansion, subroutines that are enormously deep, and fast cycle time, among other desirable characteristics. Peripheral equipment such as a "smart" CRT terminal is expected to be available, too, to make up a within-pocket-book-reach sophisticated minicomputer system.

Unlike a calculator—and we're presenting an under-$90 scientific calculator in this issue, too—computers can make logical *decisions* for an accounting system, navigation computer, time-shared computer, sophisticated intrusion system, and thousands of other applications. The "power" of *Altair 8800* is such that it can handle many programs simultaneously.

What we're presenting to you, the POPULAR ELECTRONICS reader, therefore, is a minicomputer that will grow with your needs, rather than one that will be obsoleted as you move more deeply into computerized applications. With minicomputers exhibiting an annual growth rate of some 50%, according to the E.I.A., and with predictions that six out of ten computers sold by 1975 will be mini's, you can be sure that there will be manifold uses we cannot even think of at this time.

There'll be more coverage on the subject in future issues. Meanwhile, the home computer age is here—finally.

Art Salsberg

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Ortofon VMS-20E Phono Cartridge
Lafayette Com-Phone 23 CB Transceiver
Data Technology Models 20 & 21 DMM's.

Letters

RUMOR IS NO SECRET

I was surprised to discover, in your October issue, that Radio Canada International is engaged in "clandestine" broadcasting to Russia from Sines in Portugal, over a station which (as stated on page 56) is "reported to be secretly owned by the West German government."

There was no need for the author to have recourse to rumors about the Sines transmitter, for what he advances as a conspiratorial secret is published in a more accurate version . . . in the current *World Radio Handbook*, page 92, with cross references as to users.

ALAN BROWN
Radio Canada International
Montreal, Can.

AN IC BY ANOTHER NUMBER

The Exar integrated circuit used in my "Private Messages With a Voice Scrambler" project (September 1974) has a new part number. It is now called the XR2208CP. Please advise your readers of this change.

JOSEPH B. WICKLUND, JR.
Northwest Engineering
Bothell, Wash.

SETTING THE RECORD STRAIGHT

Mr. Lancaster's series of articles on electronic music synthesizers has served a useful service to your readers. However, "Selecting an Electronic Music Synthesizer" (October 1974) contains a few inaccuracies:

1. The ElectroComp 101 is manufactured by Electronic Music Laboratories (EML), which has no connection with EMSA;
2. The Synthi 100 is manufactured by EMS (London) Ltd., who also manufacture live-performance EM systems that Mr. Lancaster failed to mention. (The Synthi 100 sells for $30,000—not $20,000);
3. Electronic Music Studios of America, Inc., (EMSA) is not a manufacturer but the American distributor for EMS (London) Ltd's products;
4. EMSA and ARP do not have the same zip code; EMSA's is 01002.

JANICE B. ANDRES
Managing Director
EMSA Inc.
Amherst, Mass.

PE ON THE AIR

Just a note of appreciation for the new larger format. You have made a great magazine a lot more enjoyable. Over the years, I have used or adopted a number of ideas presented in POPULAR ELECTRONICS here at radio station KORI (FM), a trick that often saved a great deal of time—let alone the money involved when equated against the cost of commercial equivalents.

TOM WIRCH
Chief Engineer
KSLM/KORI (FM)
Salem, Ore.

THE PARTS PROCUREMENT DILEMMA

I would like to build the "Nine-Channel Stereo Equalizer" (May 1974) but I am having difficulty finding a dealer who handles the 5558 op-amp IC's required. Another problem is that no pin numbers are shown for the IC in the schematic.

JOHN E. RICE
Georgetown, Ontario, Canada

You can obtain these IC's from Southwest Technical Products Corp. (see the Parts List in the article for the address). As for pin numbering, the omission was intentional. The 5558 is available in several package configurations, all with different lead identification.

In "Supressing Transients in Solid-State Equipment" (July 1974), it was stated that the General Electric 6RS20-SP4B4 thyrector should be available at local electronics stores. Well, I've tried six different stores within a 20-mile radius of my home and haven't been able to locate one that handles this device. Can you help me with a mail-order address?

KENNETH L. METCALF
Woodstown, N.J.

The 6RS20-SP4B4 thyrector is available from Newark Electronics, 500 N. Pulaski Rd., Chicago, IL 60624. However, there is $25 minimim for mail orders. The GE distributor nearest you is at 200 Main Avenue, Clifton, NJ 07014.

THE AMATEUR RADIO SCENE

Congratulations on the return of your "Amateur Radio" column. I was very pleased to see it in the October 1974 issue. I can hardly wait for the next column to appear. My only criticism is that the column is a quarterly; it should be a monthly.

Edward LeBlanc, VE1AMN
Prince Edward Island, Canada

In the October 1974 "Amateur Radio" column there appear to be two discrepancies in callsigns. The San Francisco station's callsign should be K101, not K-101, while I believe the correct callsign for King Hussein is JY1—nor WJ1.

Fred Becker
North Attleboro, Mass.

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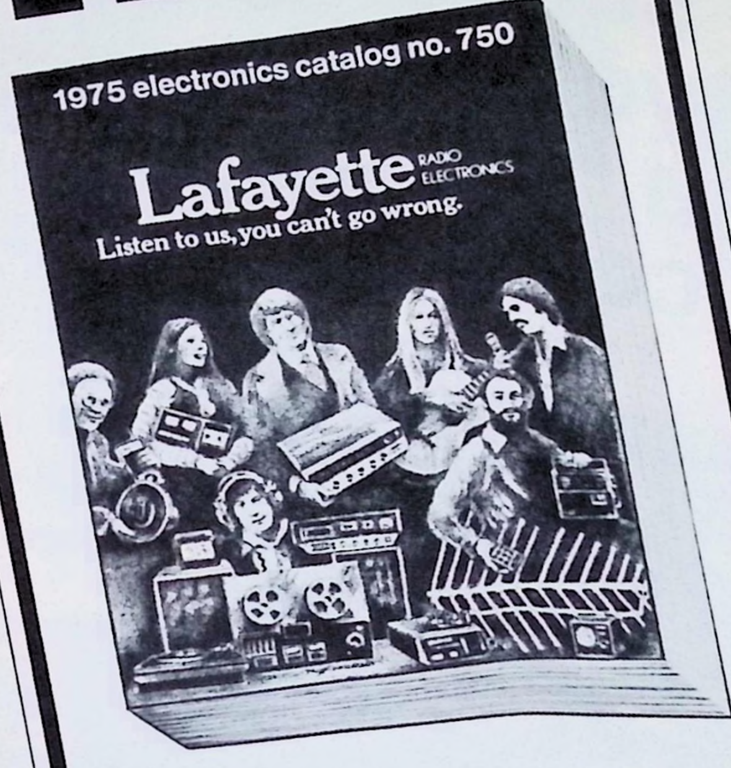
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This exclusive course trains you at home on your own digital computer! This is no beginner's "logic trainer", but a complete programmable digital computer that contains a memory and is fully automatic. You build it yourself and use it to define and flow-chart a program, code your program, store your program and data in the memory bank. Press the start button and the computer solves your problem and displays the result instantly.

The NRI digital computer is one of 10 kits you receive in the NRI Complete Computer Electronics Course. You build and use your own 3½ digit digital multimeter . . . while you perform hundreds of experiments, building hundreds of circuits, learning organization, operation, troubleshooting and programming.

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The latest in digital testing equipment . . . along with valuable training experiments in digital techniques.

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Color TV repair is another big opportunity field right now and NRI can train you at home to service and repair any color or black

NRI's complete communication course includes your own CB Training Transceiver

NRI prepares you for a career in the rapidly expanding field of communications . . . a field destined to double in the next decade! NRI can train you at home for one of the thousands of service and maintenance jobs opening in AM and FM Transmission and Reception, TV Broadcasting, Microwave Systems, Teletype, Radar, Marine Electronics, Mobile Communications and Aircraft Electronics. You train on your own 23-channel Johnson Transceiver and AC power supply; a digital multimeter, for digital experiments and precise testing; bite-

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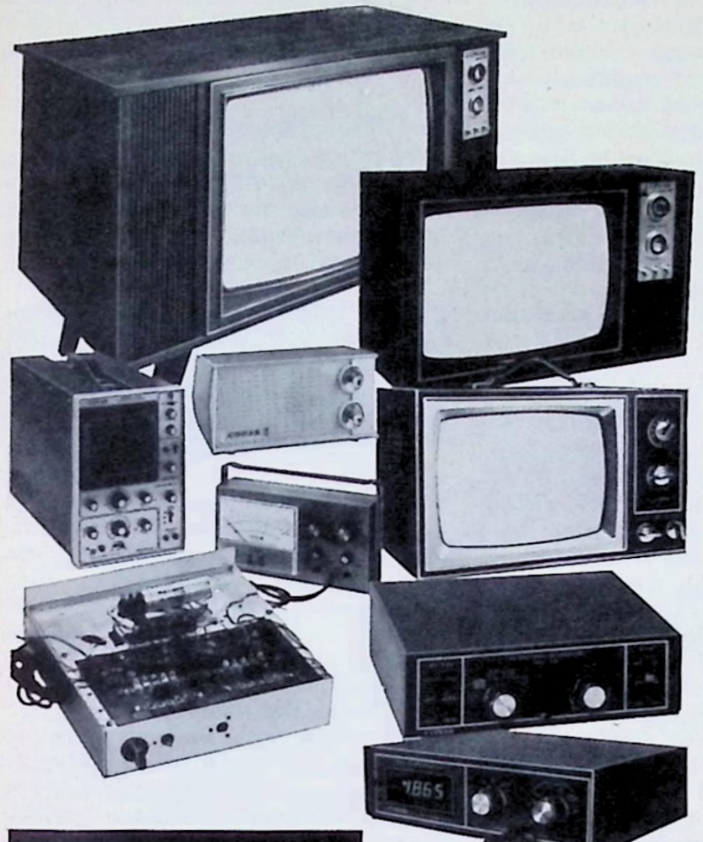

Color TV repair is another big opportunity field right now and NRI can train you at home to service and repair any color or black & white TV, hi-fi equipment, AM-FM radios, and sound systems. You can choose from 5 courses, starting with a basic servicing course with 65 lessons . . . up to a Master Color TV course, complete with 25″ diagonal solid state color TV in handsome woodgrain cabinet. No other school offers so many choices or so much value.

All courses are available with low down payment and convenient monthly payments to fit your budget. And all courses provide professional tools and equipment along with NRI-designed kits for hands-on training. With the Master Course, for instance, you receive your own 5″ wide-band triggered sweep solid state oscilloscope, TV pattern generator, 3½ digit digital multimeter and a NRI 25″ diagonal solid state television receiver expressly designed for color TV training.

YOU PAY LESS WITH NRI TRAINING AND YOU GET MORE FOR YOUR MONEY.

NRI employs no salesmen, pays no commissions. We pass the savings on to you in reduced tuitions and extras in the way of professional equipment, testing instruments, etc. You can pay more, but you can't get better training.

NRI's complete communication course includes your own CB Training Transceiver

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New Products

Additional information on new products covered in this section is available from the manufacturers. Either circle the item's code number on the Reader Service Card inside the back cover or write to the manufacturer at the address given.

HUNNICUT DIGITAL LOGIC PROBE

The model LCA-2 Logic Circuit Analyzer, made by Hunnicut Digital Electronics, displays not only the logic state of a test point but also the quality of the logic condition. Four lamps indicate voltage/logic levels: Good "0," Bad "0," Bad "1," and Good "1." The LCA-2 is compatible with DTL and TTL. Voltages up to 200 V ac or dc, claims the manufacturer, can be applied to the input. The LCA-2 is supplied with a 4-foot coaxial cable, BNC connector, and three input adapters. It can indicate polarity/duty cycle of pulse trains as high as 25 MHz. The probe measures 5½-in. long and ⅝-in. in diameter. $69.50.

CIRCLE NO. 70 ON READER SERVICE CARD

PORTABLE FREQUENCY COUNTER

The C-65A Frequency Counter by Great American Miniatures is a completely portable unit with a frequency range of 10 Hz to 65 MHz (1 Hz to 65 MHz optional). The counter uses TTL circuitry and a 6-digit LED readout. An internal nickel-cadmium power source delivers 5 volts @ 2.2 Ah. A 2.5-MHz crystal oscillator is used as a time base, and the unit can be used as a secondary frequency standard when calibrated against WWV. Sensitivity is 500 mV, and short-term stability is 1 part in 10^6/24 hours. Dimensions of the C-65A, costing $269, are 6" × 3.5" × 2.9". Weight is 27 ounces. Optional accessories include a 300-MHz prescaler, ac power supply, battery charger, coaxial probe, and a carrying case for any or all of the above.

CIRCLE NO. 71 ON READER SERVICE CARD

"ISO-TIP" SOLDERING ACCESSORIES

The Wahl Clipper Corporation has introduced a line of accessories for its "Iso-Tip cordless soldering iron. The Soldering Iron Kit (Cat. #7600) includes the iron itself (only 8" long and 6 ounces in weight) with a "safety lock" feature to prevent accidental tip heating, a wall mounting bracket, a battery recharging unit, a #7535 general-purpose tip and instruction booklet. Optional accessories include #7545 fine tip, #7546 heavy-duty tip, #7595 protective carrier and the #7585 auto charger plug assembly that fits into a car cigarette lighter for recharging in transit.

CIRCLE NO. 72 ON READER SERVICE CARD

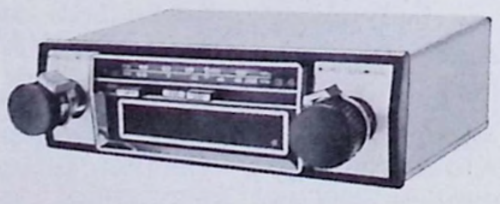
ALTEC "STONEHENGE I" LOUDSPEAKER

The Altec Corp. has introduced the Stonehenge I medium-efficiency loudspeaker system designed for use with amplifiers with a minimum 25-watt rms power capacity. The floor-standing Stonehenge I features a columnar bass-reflex enclosure, a 12" high-compliance woofer with a 9-pound magnet structure, a front-mounted dividing network with continuously-variable, high-frequency attenuation control, and a newly-designed direct-radiator tweeter. Stonehenge I is handcrafted of African Afromosian Teak veneers and complemented with a raw cocoa fabric snap-on grille, and is finished on all four sides. The system at $329, requires 1.4 square feet of floor space, and 16" × 37½" × 14½". Weight is 75 lbs.

CIRCLE NO. 73 ON READER SERVICE CARD

CLARION AM/FM MPX/8-TRACK CAR PLAYER

Clarion's new Model 608 8-track car stereo system incorporates an AM/FM multiplex radio. Among the Model 608's features are integrated circuits, vertical-head tracking to minimize cross-talk, stereo indicator light, stereo/mono switch, 4-watts rms per channel output, and a removable faceplate for in-dash installation. According to the company, the tape player has a frequency response of 50 to 10,000 Hz, S/N of 45 dB min. and wow and flutter below 0.3% .



CIRCLE NO. 74 ON READER SERVICE CARD

WHITE'S LIGHTWEIGHT METAL DETECTOR

White's Electronics announces its new lightweight, solid-state metal detector, the Coinmaster IV-4B Series II. This refined version of its earlier models boasts added sensitivity, which is governed by a variable control, a greater tuning range (both of which aid searches over highly mineralized areas), and longer battery life. A meter is included for visual as well as audible indication. Address: White's Electronics, 1012 Pleasant Valley Road, Sweet Home, Oregon 97386.

CIRCLE NO. 75 ON READER SERVICE CARD

PIONEER FRONT-LOADING CASSETTE DECK

Pioneer Electronics' Dolbyized Cassette Deck, Model CT-F7171, features front-panel access for tape loading and all necessary controls. This allows the unit to be stacked above or below other components. Its transport system is powered by a dc servo motor, for high starting torque and immunity to voltage fluctuations. Other features include separate bias and equalization for ferric oxide and $Cr0_2$ tapes, Dolby noise reduction, ferrite tape head, LED peak-level indicators, memory rewind, switchable level limiter and built-in monitoring amplifier and headphone jack. Frequency response: 40 to 13,000 Hz ± 3 dB ($Cr0_2$ tape); wow and flutter: less than 0.1% (WRMS); S/N: 58 dB (Doblyized).

CIRCLE NO. 76 ON READER SERVICE CARD

KOSS PHASE 2 STEREOPHONES

The new Koss "Phase 2" stereo headphones allow the listener to control the ambience of the program he is listening to. According to the manufacturer, the listener can either "move himself into the center of the orchestra" or "expand the musical sphere around himself." In either "location" he can accentuate selected portions of the orchestra, as if he moved toward some of the artists. The Koss Phase 2 employs Panoramic Source controls, which are thumbwheels at the lower edge of each earcup, and a two-position Ambience Expander. It can also be used in the conventional stereo mode. The medium-brown earphones are equipped with a 10-ft coiled cord and price is $75.

CIRCLE NO. 77 ON READER SERVICE CARD

JOHNSON MINI-SCAN^{tm} POCKET MONITOR

The new Johnson "Mini-Scan" vhf scanning monitor weighs only 9 ounces, (255g), while measuring 5.9"x2.6"x1.4". CMOS scanning circuitry and a newly designed low-drain audio section provide extended battery life. The unit has a four-channel capacity and a built-in ferrite bar antenna. Dual conversion and ceramic filters enhance sensitivity, adjacent-channel rejection, and good overall selectivity. The Mini-Scan is used on the 146-174-MHz band. Other features are a squelch control, built-in speaker, jacks for earphone or external speaker, and optional flexible antenna. The unit uses four AA cells and costs $119.95.

CIRCLE NO. 78 ON READER SERVICE CARD

HEATH HOME WEATHER STATION

A professional-type weather station, in kit form, is available from the Heath Company. The ID-1290 Weather Station features a solid-state thermometer that displays either indoor or outdoor temperature at the flick of a switch, a solid-state anemometer with switchable ranges for 0-30 and 0-90 mph, and an electronic wind-direction indicator with individual glowing indicators to give 16-point resolution around the compass. Sensing devices are mounted on a single horizontal mast that may be attached to a TV mast. All connecting wires are contained in one cable. The ID1290, housed in a simulated walnut panel, may be mounted vertically or horizontally and is $89.95, less cable.

CIRCLE NO. 5 ON READER SERVICE CARD

TURNER "ULTRA-KICKER" CB ANTENNA

The Turner Division of the Conrac Corp., long a leading manufacturer of microphones for two-way radios, has introduced a line of "Signal Kicker" antennas. The "Ultra Kicker" model shows an interesting combination of beam and omnidirectional configurations. It has five elements. A center folded dipole receives power from the transmission line, and is surrounded by four outer vertical dipoles, which are loaded through electronically switched stubs. The antenna can be switched to provide 8 different radiation patterns in 45-degree steps, but it remains fixed and no rotator is needed. Gain is 6.2 dB over a half-wave dipole. VSWR is 1.5:1, and the front-to-side ratio is 20 dB or better. Crossover is 0.6 dB. Two other models, an omnidirectional unit and a rotatable beam, are available at $79.95 and $119.95 respectively. Price of the "Ultra Kicker" is $239.95.

CIRCLE NO. 80 ON READER SERVICE CARD

B & K 3" TRIGGERED SWEEP SCOPE

Dynascan's new B&K oscilloscope, Model 1431, has a bandwidth from dc to 10 MHz, and a sensitivity of 10 mV per division. In addition to the triggered sweep, sync is fully automatic. A three-step vertical attenuator is included, and sweep time is variable from 0.5 µs to 0.5 s per division, in 19 calibrated regions, and 5X magnification is available. Rise time of the vertical amplifier is 35 nanoseconds, overshoot is 3% or less, and the input impedance is 1 megohm shunted by 35 pF. The 1431 is supplied with a handle/tilt stand, Mylar vector overlay (so the unit can be used as a vectorscope), but less probe. It is $399.00.

CIRCLE NO. 81 ON READER SERVICE CARD

FANON TRANSISTORIZED MEGAPHONE

The Fanon Model MV-5S is a combination megaphone and warning signal in high-impact plastic bell and housing. Rated output of the amplifier is 5 W with a 300-yd range. Unit has a built-in weatherproof, dynamic mike, pistol-grip talk/signal switch, adjustable volume, and horn alarm. Power is furnished by six "C" cells. $69.95.

CIRCLE NO. 82 ON READER SERVICE CARD

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the price for moving up to a sweep/function generator just came down to $149.50

Exact now offers a laboratory-quality sweep/function generator at a price you'd pay for less-useful sine-square oscillators. And you'll get so much more out of the new Model 195 than traditional audio test equipment, such as sine, square, triangle and swept waveforms . . . even pulses.

This new 2 Hz to 200 kHz instrument is the practical answer to many of your signal source needs, whether you're checking audio equipment, testing breadboarded circuits or teaching at the high school or college level.

An internal sweep generator lets you sweep, either linearly or logarithmically, the entire audio range of amplifiers or speakers without changing ranges or even touching a knob. The Model 195 has three 1000:1 sweep ranges for frequency sweeping plus high and low level sine outputs with amplitude control. Or you can control the frequency by an external voltage (VCF).

The Model 195 is completely portable, operated by a 9-volt transistor battery, so you can forget 60-Hertz hum problems altogether. An optional rechargeable power supply and charger permits continuous operation from Ni-Cad battery power.

This is a true instrument . . . developed by by one of the world's leading designers and manufacturers of laboratory function generators and frequency synthesizers. Find out what the Model 195 can do on *your* bench, and move up to a better source of signals.

Price: Model 195 $149.50
Optional rechargeable power supply, complete with battery and charger $25.00 f.o.b. Hillsboro, Oregon. Instruments stocked in 36 locations across the United States.

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Read what the experts say about Heathkit Digital-Design Color TV

> *"The picture on the GR-2000 can only be described as superb. The Black (Negative) Matrix CRT, the tuner and i-f strip, and the video amplifier provide a picture equal to that of many studio color monitors."*
>
> (Popular Electronics, April, 1974)

> *"The picture quality of the GR-2000 is flawless, natural tints, excellent definition, and pictures are steady as a rock. It's better than any this writer has ever seen."*
>
> (Family Handyman, June, 1974)

> *"The plain truth is, with service and repair costs soaring even for the most insignificant in-home repair, the GR-2000 is the way all color TV sets will have to be made in the near future...."*
>
> (Elementary Electronics, May-June, 1974)

25" (diagonal) Heathkit GR-2000

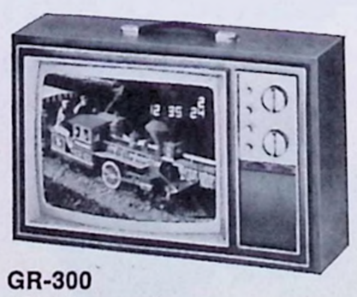
Widely reviewed and acclaimed for its outstanding picture and years-ahead engineering. At the touch of a button, the channel number appears on the screen. The optional clock module displays the time right under the channel readout. The totally solid-state varactor tuner eliminates noisy "clunkers" with contacts that can wear out. Instead, pressing a button silently selects any of the 16 pre-programmed UHF or VHF stations. The unique fixed-filter IF never needs instrument alignment, so pictures retain unmatched clarity and brilliance year after year. And for the ultimate in convenience, add the optional wireless remote control. The GR-2000 can be custom mounted and optional cabinets start at $119.95*.

Kit GR-2000, less cabinet, 147 lbs., Exp./frt.	669.95*
Kit GRA-2000-1, Digital clock module, 1 lb., mailable	29.95*

Now–a new generation of Heathkit small-screen color TV with digital readout

GR-500
19" (diagonal)

GR-400
17" (diagonal)



GR-300
15" (diagonal)

Simulated TV pictures

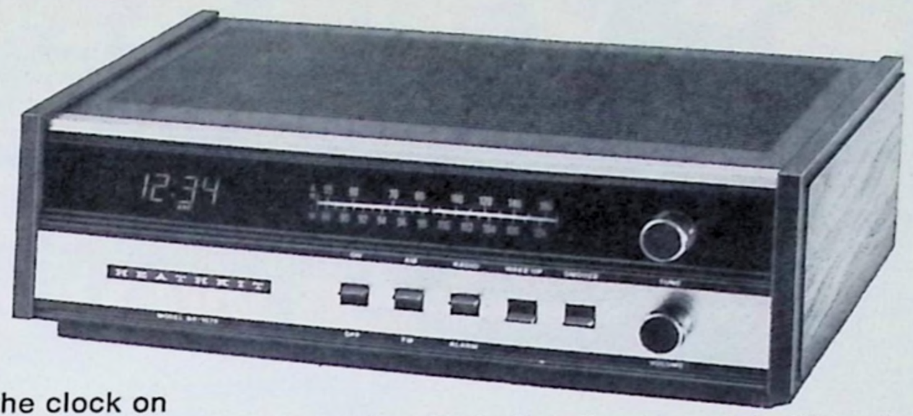
Famous Heathkit quality in your choice of screen sizes — 15, 17 or 19" (diagonal). They all have GR-2000-inspired digital channel readout and optional plug-in clock modules. And in the tradition of the GR-2000, these TV's feature dozens of design innovations. Each uses a precision in-line gun in the picture tube and a slotted shadow mask for a bright picture. The GR-400 and 500's negative-matrix screen provides superior contrast while luminance and video circuits with black level clamps maintain the true brightness of televised scenes.

A factory-sealed static toroid yoke and magnet assembly completely eliminates convergence and purity adjustments — and the picture is superior to sets requiring manual adjustments.

The list of significant advances goes on and on — dual gate FET mixer, FET RF amplifier, 4 tuned circuits (instead of the 3 most sets have), automatic fine tuning and preset picture control, hi-fi output jack, slide out chassis. The GR-300 and 400 come complete with walnut veneer cabinets, cabinets for the GR-500 start at $39.95.

Kit GR-500, less cabinet, 88 lbs., Exp./frt.	499.95*
Kit GR-400, with cabinet, 104 lbs., Exp./frt.	489.95*
Kit GR-300, with cabinet, 90 lbs., Exp./frt.	449.95*
GRA-2000-1, clock module for GR-300, 400 & 500, 1 lb., mailable	29.95*

6 unique new Heathkit products you can build yourself



Heathkit AM/FM Digital Clock Radio—

The GR-1075 is no ordinary clock radio. Big, bright Beckman planar gas discharge tubes display the time. The readouts adjust their brightness automatically as room lighting changes.

A standby battery power supply keeps the clock on time (without the display) if the electricity is interrupted. When the power is restored, the 24-hour alarm will be on time—and so will you. You can wake to your favorite station or a gentle electronic "beep" with adjustable volume. And the radio section uses the same design philosophy as our famous AR-1214 stereo receiver including fixed ceramic filters in the AM and FM circuits and a factory-assembled and aligned FM front-end with 5 μV sensitivity. With 4 IC's, 41 transistors and 35 diodes, the GR-1075's design is years ahead of ordinary clock radios.

Kit GR-1075, less batteries, 10 lbs., mailable, **129.95***

Digital Electronic Car Clock/Timer

The GC-1093 is an accurate timepiece for your car, boat or plane. It's an electronic clock and a 20-hour rally timer, both with quartz-crystal accuracy. Bright ½"-tall digits dim automatically at night. 12 VDC, mounts on or under the dash.

Kit GC-1093
2 lbs., mailable
62.95*

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HEATHKIT

Desktop Electronic/Sliderule Calculator

At last, a sliderule calculator that's big enough to use. The IC-2100 has finger-sized keys and a bright, ½"-tall 8-digit display. Cumulative memory and register exchanges virtually eliminate scratchpad work. Performs arithmetic plus trig and arc trig in degrees or radians, common and natural logs, powers of e, square roots, inverses, pi and exponential functions.

Kit IC-2100
4 lbs., mailable
119.95*

Dual-Trace Oscilloscope

A professional scope at kit-form savings. DC-15 MHz frequency response, post-deflection accelerated CRT, vertical amplifier delay lines, time base up to 100 nsec/cm, guaranteed to trigger up to 30 MHz (typically up to 45 MHz), 1 mV/cm vertical sensitivity, true X-Y capability.

Kit IO-4510
34 lbs., mailable
549.95*

Digital Electronic Clocks with standby power

The GC-1092A is a digital clock with a snooze alarm; the GC-1092D reads the time in 6 digits, the month and date in 4 digits. Both have standby power supplies to keep the clock on time (without the display) even during power interruptions.

GC-1092 A & D,
less batteries, 5 lbs., mailable ....**each 82.95***

GC-1092A Time/Alarm

GC-1092D Time/Date

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New Literature

METHODE ELECTRONICS PC BROCHURE

"Printed Circuits," a new brochure from Methode Electronics is a 16-page description of various types of printed circuitry including single-sided etched and coated boards, double-sided etched and plated-through types, additive plated-through-hole circuits, and multi-layer and flexible boards. The brochure is well-illustrated with explanatory diagrams and photographs. Methode's several multi-paneling concepts are described: "crackerboard," scored-array, "nested-array," and web-matrix panels among them. Address: Methode Electronics, 7447 W. Wilson Ave. Chicago, IL. 60656.

1974 NATIONAL MOS CATALOG

The new edition of National Semiconductors Corp.'s MOS IC catalog is now available. This latest book contains over 500 pages of design and applications information on the broad National line of standard MOS products, including clocks, calculators, and memories. Complete information can be found on National's eight- and nine-digit calculator circuits, digital clocks for desk-top, alarm and automobile applications, shift registers—both static and dynamic, semiconductor memories, including ROM's, PROM's, and RAM's, character generators, code converters, and microprocessor elements. Address: National Semiconductor Corp., Marketing Services Dept., Santa Clara, CA 95051.

LAFAYETTE 1975 CATALOG

The latest edition of the Lafayette Radio Electronics catalog is now available free upon request. It contains over 18,000 items in the consumer electronics field including stereo and 4-channel components and music systems, CB, ham, and PA gear, test equipment, antennas and security devices, musical instruments, cameras and optics, calculators, and many types of parts required in electronic projects. The format of the publication has been changed—page size has been increased 45%; larger type and more color have been used; audio equipment has ratings in full compliance with the latest FTC regulations; and major brand lines have been given expanded coverage. The catalog may be obtained at Lafayette stores or write to: Lafayette Radio Electronics, Dept. PR, Box 10, Syosset, NY 11791.

AUTHORITATIVE TIME AND FREQUENCY TEXTS

A comprehensive collection of information, theory, and data on time and frequency (T/F) standards has been released by the National Bureau of Standards. Monograph 140, ($8.65), "Time and Frequency, Theory and Fundamentals," describes the field of T/F research, from basic concepts of the measurement of time to the latest developments in precision timekeeping based on atomic and molecular resonances.

Technical notes supplement the monograph. NBS Technical Note 649 ($1.00), "The Standards of Time and Frequency in the USA" is also one chapter in the monograph. It describes the activities of the two agencies chiefly involved in the T/F field—the NBS and the Naval Observatory. Technical Notes 616 (Revised) ($5.70) and 656 ($.35) deal with "Frequency Standards and Clocks: A Tutorial Introduction" and "Standard Time and Frequency: Its Generation, Control, and Dissemination by the NBS," respectively. A discussion of the broadcasts of radio stations WWV, WWVH, WWVB, and WWVL can be found in the latter Technical Note. The publications are available from the Government Printing Office, Washington, DC 20402.

RCA LINEAR IC WALL CHART

Available from RCA is a quick-reference wall chart giving data on their linear IC's for communications, control, instrumentation, and information systems applications. Included on the chart (Form No. LIC-247A) are op amps, arrays, differential amplifiers, broadband (video) amplifiers, voltage regulators and thyristor control devices, AM/FM communications circuits, comparators, and analog multipliers. It also includes a cross-reference of direct replacement types for the products of 12 other manufacturers. Address: RCA Solid State Division, Box 3200, Somerville, NJ 08876.

1975 RADIO SHACK CATALOG

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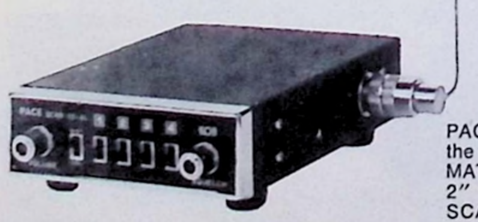

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Stereo Scene

By Ralph Hodges

MIKES AND MIKING

ALL RIGHT, you want to buy a good microphone so you go for advice to the experts—the recording engineers. And a fat lot of good that does you! Recording engineers today use not one but *many* microphones, all of which they consider "good" for a particular application.

For example, John Woram, a highly experienced studio man and professional consultant on recording matters, frequently rhapsodizes on the various characteristics of mikes in professional sound recording magazines. As John tells it, an engineer might want to use a moving-coil mike with a rather undistinguished high-frequency response to capture a firm, slightly juicy splat from the kick drum (the pedal-operated bass drum in a drum set), while employing a dead-flat condenser pickup to bring out the dry rustle, sting, and snap of the snare drum. In fact, a drum set, which really constitutes only one instrument in a pop ensemble, may have as many as three to six different microphones hovering above, around, or *in* it.

And we can go on. An electric guitar or electric bass consists of the instrument itself as well as the inductive pickups below each string and the amplifier/speaker conglomeration from which the sound emerges. The engineer has the choice of miking acoustically through its speaker (which is, after all, part of the "sound" of the instrument), or running a direct feed from the guitar's pickups or amplifier to the recording console. On occasion he's been known to do both, either mixing the two signals on the spot or laying them down in separate tracks on the tape for subsequent mixing. And perhaps he wants to mike the guitar in stereo to give a greater sense of the acoustic field. (Many engineers do not, preferring to make a mono recording of the instrument and then control its position in the stereo "spread" by feeding more or less of it to the left or right channel of the final record.) Thus the engineer may use a minimum of *three* microphones,—if you count the guitar's pickups—to get the sound he wants from *one* musician. And today he also has the option of using nonacoustic devices that fasten on the instrument and pick up mechanical vibrations.

All of these implements can be brought to bear selectively, according to the way his *taste* tells him an instrument should sound for a particular recording. Ultimately, recording studios acquire reputations for the special noises they seem to be able to get, or even for the sympathetic touch they give certain instruments.

Recording studios frequently use microphones in an unorthodox fashion. For example, now and again they put a mike *inside* the bass drum. You wouldn't want to do this with one of the excellent, but generally fragile ribbon microphones of years past, because the first thud hitting the diaphragm would simply blow it away. Few, if any, condenser mikes available could stand the punishment without distorting severely. So you take the overload factor very seriously in professional recording work.

Many of these considerations are of no importance for the amateur recordist. You and I do not and never will have on hand the collection of Neumann's, RCA's, AKG's, Sennheiser's and now Sony's that the big studios can inventory. *We* work with two or three mikes at maximum, hanging them out in space where they're not likely to get overloaded by any one instrument, and we record the performance as an ensemble effort, not as individual instruments.

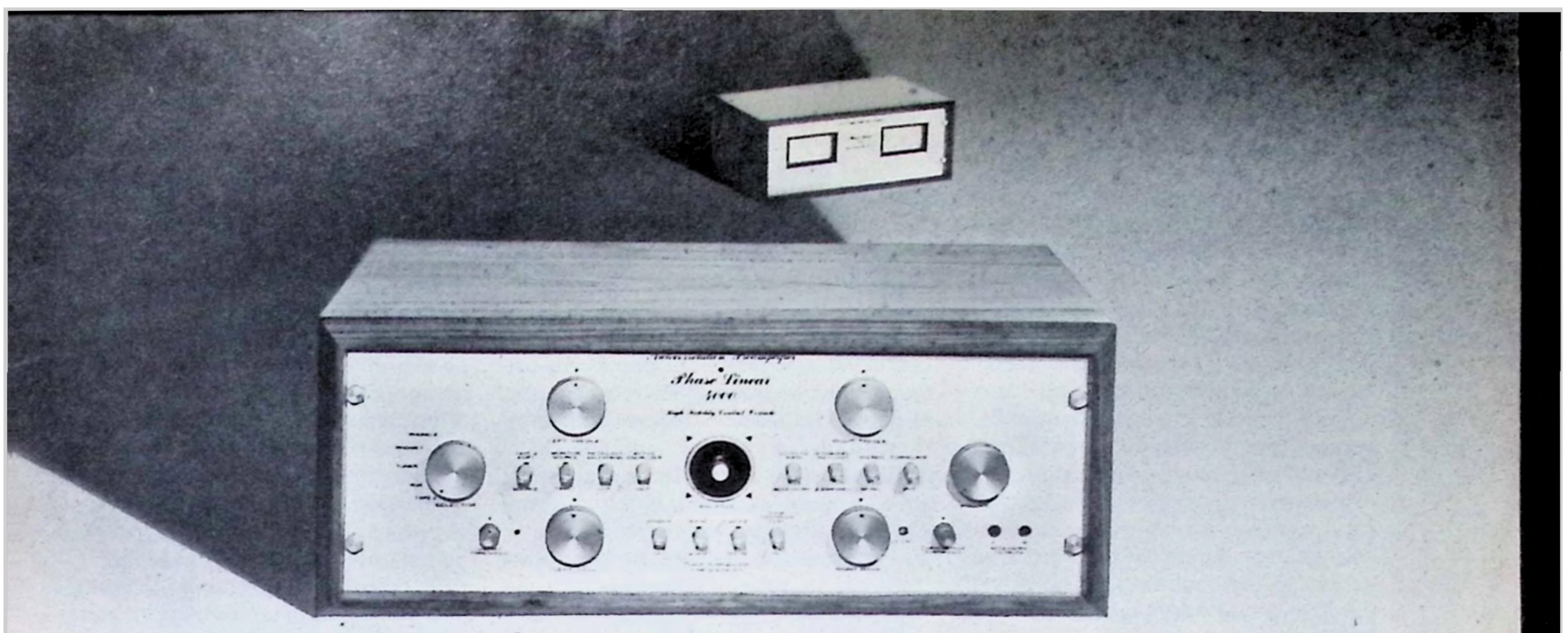
For these purposes, I favor the flattest frequency response possible in a microphone. This is not the obvious choice that it first appears to be, and it's possible that many amateur recordists (and certainly many pros) would disagree. For example, a mike intended for close-up work, especially for voice, might have a gradually descending low-frequency response, and perhaps a bump in the upper mid-range. These characteristics, compensate for an emphasis of lows that most directional mikes exhibit at close range ("proximity effect"), and also improve articulation. Fine, but I'm usually out in the boondocks worrying about anything but proximity effects.

Now and again, I do feel a need for the mid-range bump (often called "presence boost") and wish I had it. But under my normal working conditions (frequently my first hearing of the music comes when the tape starts rolling and the performance begins), I have neither the time nor inclination to mess with such esoterica. (I should mention that proximity-effect compensation and even presence boost can be cut in or out by switching on the cases of some microphones.) So I prefer flat frequency response, for the kind of recording I do.

Frequency Response. Frequency-response data for a microphone can be obtained by measuring its simple electronic output with a meter. You don't have to mike a complex acoustic field as you do with a speaker. But microphone and speaker testing share a common problem: like speakers, microphones are directional, sometimes by accident (diffraction effects of the case on sound trying to reach the diaphragm, for example) and often by design. The two most common microphone directional types in the amateur's inventory are the *omnidirectional*, meaning a mike that responds equally to sounds impinging from all directions (or tries to, anyway); and the *cardioid*, which describes a microphone that attempts to respond fully to sounds in front of it (wherever its front happens to be) and not at all to sounds approaching from behind it. The polar graphs in Figure 1 illustrate these pickup patterns; imagine the circle of the omni to be a full sphere, and the cardioid's pattern as a ripe tomato viewed from the side.

Why would you use a directional microphone like a cardioid? Obviously, you'd use it if you didn't like something coming from behind. This could be audience noise or room/concert-hall reverberation, particularly if it echoes, sounds otherwise nasty, or is just excessive.

There are other directional types, too, such as the *bidirectional*, exhibiting a figure-eight polar re-



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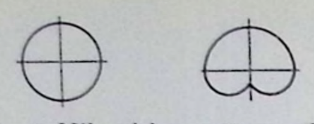

Fig. 1. Mike pickup patterns: (left) ominidirectional; (right) cardioid.

sponse (or, to continue the three-dimensional analogies, a crudely formed dumbbell with no place to grab onto), and the *supercardioid* and *hypercardioid* varieties, which narrow the cardioid's tomato down into a pepper (sometimes even a chili pepper) shape, usually with some leafy growth at the stem indicating less than total success in eliminating rearward sounds. Some of these are beloved by professionals, either for their pickup patterns or for other special qualities. But they are rarely part of the amateur's equipage.

Back to frequency response. The sound-output pattern of a loudspeaker can also be shown with polar plots. But as any casual audiophile knows, the polar pattern will not be the same at all frequencies. Lows tend to become omnidirectional, while highs may begin to "beam" in a tight supercardioid fashion. So it is with microphones, although their directional aberrations are not always the same. Figure 2 shows the polar plots for a cardioid mike at several different frequencies, while Fig. 3 gives its various frequency responses for sounds originating at zero degrees (right in front, or "on axis"), and at several angles off axis. If the polar plot of Fig. 2 showed the pickup patterns for all frequencies, you could draw Fig. 3 directly from it.

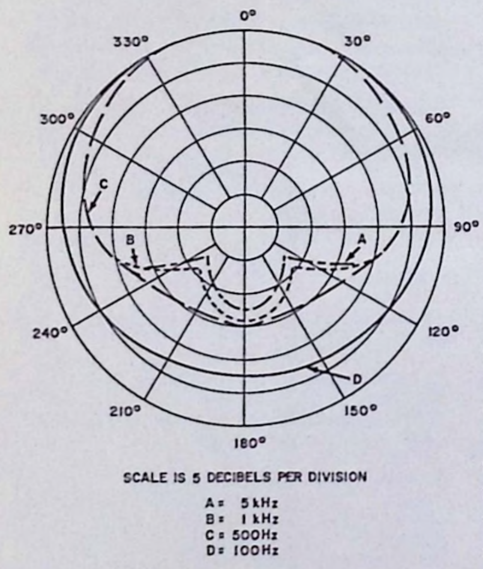

Fig. 2. Cardioid pickup patterns at four different frequencies.

What does all this mean? Well, as you may know, the frequency response you hear from a speaker in a room is a combination of its numerous frequency responses at various angles, since reflections from room boundaries ultimately bring to your ears the speaker's output at 60 degrees, 90 degrees, 180 degrees, etc. And the frequency response of a microphone (i.e., what *it* "hears") is also a composite of its various responses at all angles, since it's picking up the same sort of room reflections.

It follows (or so it seems to me) that the *real* frequency response of a microphone is not the simple on-axis curve, but some kind of summation of the curves in Fig. 3 and many others besides, all adjusted for the reflectivity of the particular recording environment. But since you can't predict the nature of the recording environment, you're ultimately best off, I'd imagine, with a mike whose response changes little with incident angle. The microphone of Figs. 2 and 3 is not too bad in this respect. Others will be better still, and some will be worse. And for some microphones you may be interested in, the relevant data of this kind will prove difficult to get, I'm afraid, even from the manufacturer. But we all do our best.

Microphone Types. There are only three microphone types that interest the serious recordist: moving coil, ribbon, and condenser. The moving coil closely resembles a speaker (and especially a dome-type tweeter) in construction. In operation its cone (or dome) is shuttled to and fro by impinging sound, and the magnet assembly induces an output voltage in the coil that moves with it. The ribbon type employs a low-mass diaphragm of corrugated metal foil that is also the inductor as it moves within a magnetic field. Condenser microphones consist of a light diaphragm in close proximity to a conductive plate. The diaphragm is polarized—either by an external dc voltage source or with a built-in (electret) electrostatic charge—and as it moves relative to the stationary plate in response to air-pressure changes, the varying capacitance modulates the output voltage.

The time was when the high-frequency responses of these three types were a function of their diaphragms' inherent moving masses, and ranged from dismal to marginal (moving coil), better (ribbon), and best (condenser). Improved materials and construction have made remarkable strides in narrowing the gap, so that on a dollar-for-dollar basis you can get perfectly acceptable—if not identical—results from any. Of course, ribbon mikes are complex in construction and not really available below $100 apiece. But at around $150 you might well pick a ribbon over moving coil or a condenser.

Then there is the question of ruggedness and resistance to acoustic overload. To my knowledge I've never had a mike physically overload, but then I don't work close up as a rule. If you plan to, then you should know that moving-coil types are considered best at shrugging off the very high sound-pressure levels that come from brass, drums, electronic instruments, etc. Some condenser jobs come fairly close, but few condensers can always be trusted in these applications. Ribbons used to have a terrible reputation for going mechanically to pieces at the slightest provocation, and sometimes suffering permanent injury. Many of the breed are still quite delicate, but Beyer claims that its ribbons can tolerate sound-pressure levels in excess of 130 dB—well into the moving-coil class; and the Group 128 condenser mikes are said to be equally rugged.

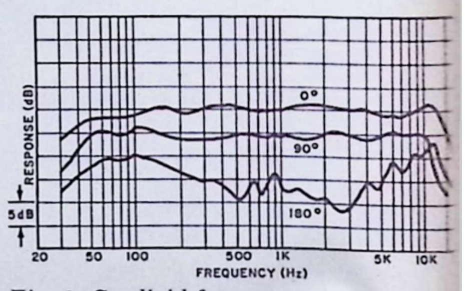

Fig. 3. Cardioid frequency response on axis and at two angles off-axis.

As for directional properties, moving-coil and condenser mikes can be made to exhibit practically any pickup pattern. The same is theoretically true for ribbons, but I don't know of any omnidirectional ribbon mikes.

Incidentally, lest I have frightened anyone away with my brief reference to prices above, let me say that fine moving-coil and electret-condenser mikes can be had for $50 and less.

Impedance, Sensitivity, Etc. These topics frequently form the bulk of microphone how-to-buy articles. I plan to give them very short shrift.

It is imperative, when using longish microphone cables, to set yourself up with low-impedance mikes, which avoids certain noise and high-frequency loss problems. Recognizing this, every modern tape-recorder manufacturer I can think of has designed his microphone inputs for low-impedance mikes ("suitable for microphone impedances from 150 to 600 ohms" is a typical "specification"). Almost any microphone with true audiophile appeal is going to be available within that range. Some can be switched to higher impedance.

Sensitivity (which is voltage out, for such-and-such a sound-pressure level, into such-and-such an impedance) is trickier. I like a high-output mike because, again, I prefer to keep my microphones somewhat away from the instruments, and sound-pressure levels are lower out there. Therefore I'm often happiest with a condenser, which has and needs its own amplifier (often built into the microphone case these days, and powered by an integral penlight dry cell). Thus, a condenser can have just about any output it pleases, and it may not care a lot about load impedance either. (But there is an additional noise specification—the noise contributed by the microphone's amplifier—to consider.) Mikes with excessively low output would get me into signal-to-noise trouble with my recorder's preamps, however. And excessively high outputs might get the close miker into trouble, since the microphone inputs of most audiophile recorders have electronics *before* the record-level controls, and these can overload. But a passive attenuator consisting of a simple resistor network—available from Shure, Electro-Voice, and others, installed in a case for easy microphone line insertion—will take care of that.

Few desirable microphones in realistic (for us) price ranges vary so much in output from the norm that a way couldn't be found to make a decent recording of, say, voice and acoustic guitar. But when you try to discover the *optimum* mike for your machine, you find you need noise and overload data for your microphone inputs, comparable sensitivity specs for different brands of microphone (and they're not really comparable at present), and some very difficult-to-get (or believe) data about live-music levels. (Argh!) Instead, I recommend you consult your tape machine's manufacturer. In many cases he'll have had a chance to use the mike that interests you, and has some insights.

Contacting the manufacturer could be particularly helpful if you plan a major purchase. But don't just write and say, "Which microphone should I buy?" Familiarize yourself with what's available, narrow your choices down to a few, and let him suggest a final decision in the light of your expressed (in your letter, concisely) recording intentions.

As I've said, I prefer to mike a little distantly. This is because I get a good dose of hall reverberation mixed into the final result, and since being well back in the hall is the perspective from which I'm used to hearing performances, it sounds truer to me. (By the way, when I say "mike distantly," it means that the microphones are usually at stage edge or a little beyond, and from seven to twelve feet up.)

I get all kinds of arguments about my technique, and I pay them no attention whatever. True, my tapes would be too dim and muddy for AM radio play (although I absolutely insist they sound fine through good speakers); and for most commercial purposes, they would probably be considered hopeless. Who cares? I'm in business to please myself, not the mass millions. I get the kind of sound I wish I could get on more commercial recordings, and that is the reason I willingly lug tape machine, mikes, headphones, mike stands, cables, and miles of tape through dark Manhattan nights in quest of musical events.

For like-minded souls wishing to learn about microphones, I can recommend Lou Burroughs' *Microphones: Design and Application,* from which I've freely borrowed for this column and its illustrations. It costs an outrageous $20 (plus tax and postage, I'm sure) from Sagamore Publishing Co., 980 Old Country, Road, Plainview, N.Y. 11803, but it is a truly fine and comprehensive text, with revelatory advice on maintenance.

Correction. An error appeared in my November 1974 column on speaker failure. In the discussion of woofer-cone offset, the text referred to dc amplifier voltages that "may appear at the output capacitors." The sentence should have read, "may appear at the outputs of direct-coupled amplifiers using *no* capacitors." ◈

Model AT15S cartridge shown
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CIRCLE NO. 6 ON READER SERVICE CARD

news HIGHLIGHTS

Philips & MCA Market Video Disc

N. V. Philips, based in the Netherlands, and MCA, Inc., Los Angeles, have reached an agreement for marketing a Philips/MCA video-disc player and compatible discs for consumer use. An official of MCA states that this development will result in the interchangeability of their video discs. The companies will establish a licensing organization to negotiate with others for related patents. It is expected that a liberal licensing policy will enable many companies to participate in the video player technologies of both concerns. The Philips/MCA video-disc player will be manufactured and marketed by Philips, while MCA, whose resources include the Universal Pictures film library, will produce and market video disc programs.

Blank Tape Sales Skyrocketing

Nearly 200 million blank cassette tapes and 30 million blank 8-track cartridges will be purchased this year, according to the Longines Symphonette Company, a major producer of such tapes. The company also states that cassettes, though now considered a hi-fi medium, are being used for speech recording as well as music. Students are recording their lectures, and businessmen are taping their conferences on cassettes. These new demands, according to a Longines sales projection, will push the total cassette purchases in 1976 to top 340 million. This represents an increase in sales at the rate of 50 million more new cassettes per year.

RCA Introduces Hybrid OP Amps

RCA's Solid State division has introduced a family of hybrid op amps that combine the advantages of MOS/FET's, bipolar transistors, and COS/MOS on a monolithic chip. Gate-protected PMOS transistors are used in the input circuits of the CA3130 family, to provide very high input impedance, low input current, and high-speed performance. The common-mode input-voltage range goes to 0.5 volts below the negative-supply terminal. A bipolar driver provides voltage gain. A COS/MOS drain-loaded inverting amplifier comprises the output stage operating in the Class A mode. The output can be swung within millivolts of either supply rail when used with highly resistive loads, and the gain of this stage depends on the load impedance. Open loop gain of the op amp is 110 dB and bandwidth is 15 MHz. The CA3130 series can be used as comparators (COS/MOS interface), wideband amplifiers, voltage regulators and followers, and in timing applications.

Data Transmission on Real-Time TV

A new system of encoding information on broadcast TV signals has been introduced by the Atlantic Research Corp., Alexandria, Va. The Data-Dot^{tm} system modifies the video signals to cause a small dot to appear in a corner of the receiver's screen, which carries one or more channels of information. A peanut-sized optical sensor is placed over the dot, and decodes the information which can be printed, displayed, or recorded by a variety of terminal devices. The manufacturer says that modules can be used without any modification of the TV receiver. This system has many possible uses. It can provide data to accompany any televised event—performance records of a player involved in a sports competition, historical information on dramatic characters, even stock market and news reports!

"Under New Proprietorship"

GTE Sylvania and Philco-Ford jointly announced an agreement under which the former would acquire the Philco name and distribution rights for home entertainment products manufactured by Philco-Ford's Home Products Division, and sold in the U.S. and Canada. The agreement does not involve Philco-Ford's line of home refrigerators and freezers, its Telesound operations, or its automotive products. In another development, North American Philips Corp. acquired about 85 percent, or 15 million shares, of the outstanding stock in the Magnavox Company.

Trends in the Microwave Industry

The microwave products industry represents 8 percent of the total electronics industry, and generates $2.2 billion annually in economic activity. This figure is expected to grow to $2.8 billion by 1983, according to a report assembled by the Business Communications Company, Stamford, Conn. A large (7.5 percent) annual growth is predicted for the microwave oven field.

Private-Use TV Station

A new television station, available for private use, has opened in New York City. It is part of a new service authorized by the FCC, called Multipoint Distribution Service. The new medium, named "Private Television," is to be utilized by business, government, and entertainment users to deliver their programs at lower cost than is possible via other available means. . . . Owned and operated by the Microband Corp. of America, the station has its control center located in the Empire State Building and will provide its full-color private TV transmission facilities to various locations throughout the tri-state area. . . . The station comes under FCC common-carrier regulations, which restrict its activity to program distribution only. Customers select the transmission time, as well as the individual receiving points, and control the program content. Multiple Distribution Service (MDS) uses microwave frequencies (2150 MHz) and a system of address-encoding to assure program privacy. . . . Microband is affiliated with MDS stations in other cities through a national system that plans to use domestic communication sattelites to interconnect them in a national private TV network. Stations are presently in Washington, D.C., Chicago, Houston, Baltimore, and Philadelphia. Coverage for Miami is expected soon.

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A few of the areas where the mitScope is an excellent tool for diagnosing problems are: electronic calculators; digital clocks and timers; digital automotive electronics; and many more.

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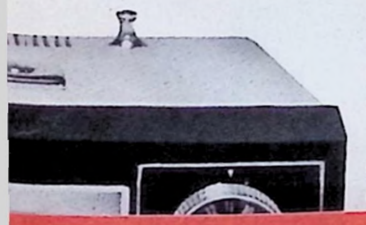

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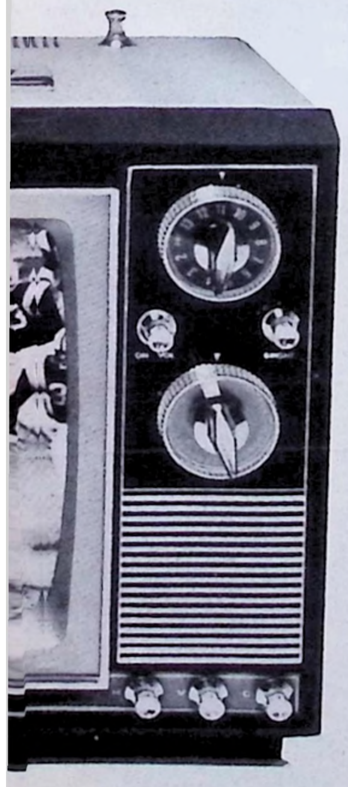

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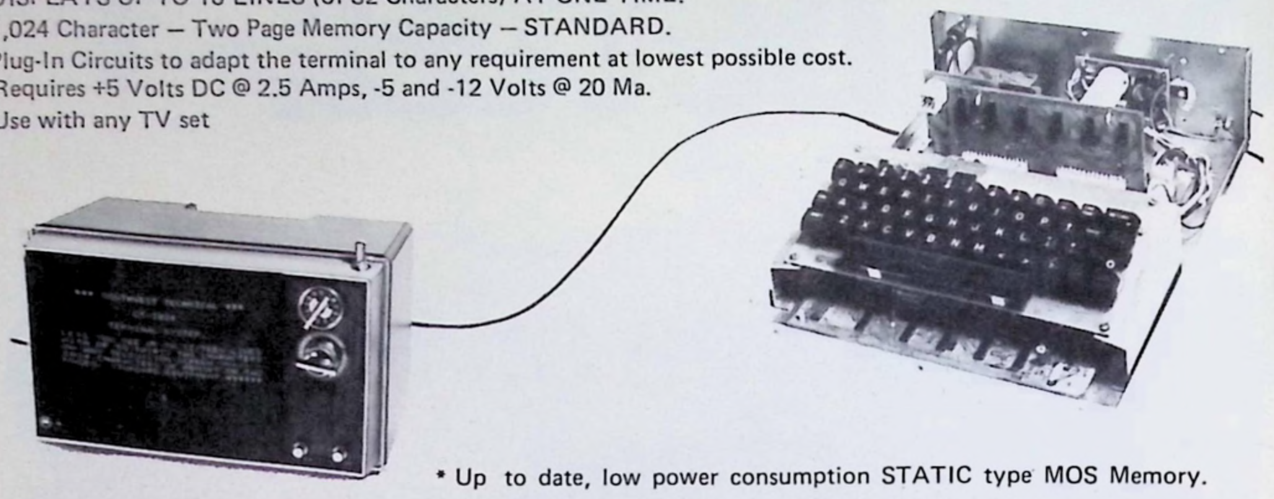

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Other applications of a terminal system such as remote time share, RTTY, etc require an interface having a serial output. For these applications you add our# CT-S plug-in UART card to the mother board. This allows you to transmit and receive ACSCII coded data in serial form at a rate of 110 baud. (300 and 600 baud options are available). The standard RS-232 type interface connects directly to your transmitter FSK modulator, modem system, or what have you.

If you are going to use the CT-1024 directly with a computer I/O port that requires a parallel ACSCII input, then you will want our parallel interface card, #CT-P which allows either the keyboard, or the computer to access the terminals memory and display data on the screen.

For those applications where it is useful, we also have an "off line edit", or "screen read" plug-in circuit #CT-E. This allows you to compose a program, or message on the terminals display screen and transmit it out a line at a time when you are finished and satisfied that everything is correct.

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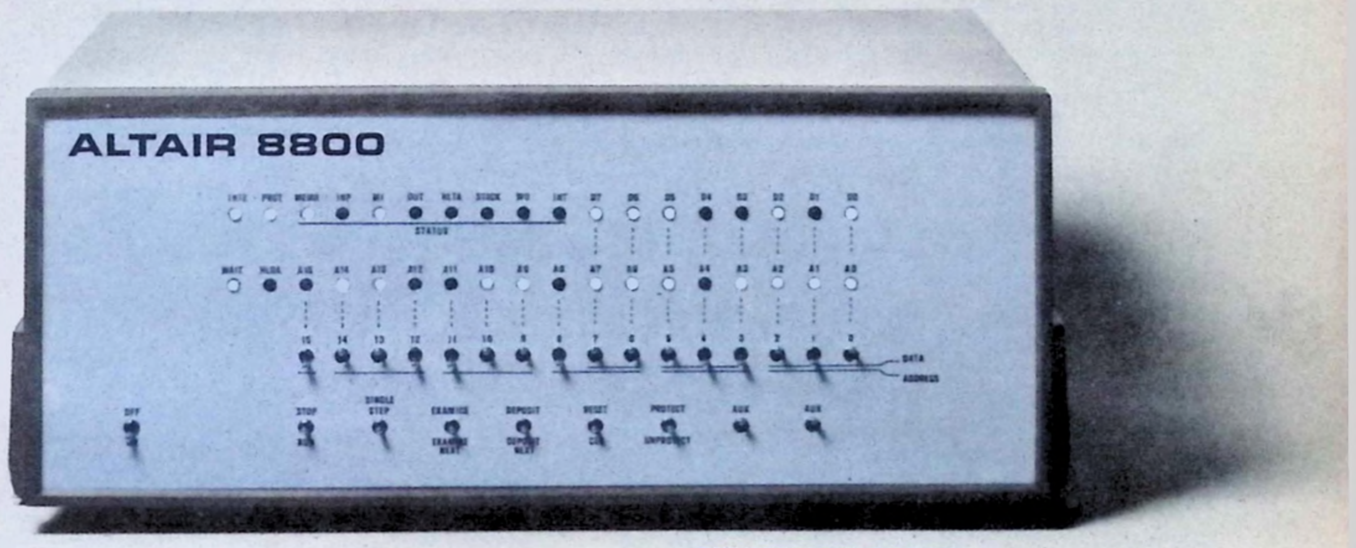

BY H. EDWARD ROBERTS AND WILLIAM YATES

THE era of the computer in every home—a favorite topic among science-fiction writers—has arrived! It's made possible by the POPULAR ELECTRONICS/MITS Altair 8800, a full-blown computer that can hold its own against sophisticated minicomputers now on the market. And it doesn't cost several thousand dollars. In fact, it's in a color TV-receiver's price class—under $400 for a complete kit.

The Altair 8800 is not a "demonstrator" or souped-up calculator. It is the most powerful computer ever presented as a construction project in any electronics magazine. In many ways, it represents a revolutionary development in electronic design and thinking.

The Altair 8800 is a parallel 8-bit word/16-bit address computer with an instruction cycle time of 2 µs. Its central processing unit is a new LSI chip that is many times more powerful than previous IC processors. It can accommodate 256 inputs and 256 outputs, all directly addressable, and has 78 basic machine instructions (as compared with 40 in the usual minicomputer). This means that you can write an extensive and detailed program. The basic computer has 256 words of memory, but it can be economically expanded for 65,000 words. Thus, with full expansion, up to 65,000 subroutines can all be going at the same time.

The basic computer is a complete system. The program can be entered via switches located on the front panel, providing a LED readout in binary format. The very-low-cost terminal presented in POPULAR ELECTRONICS last month can also be used.

PROCESSOR DESCRIPTION

Processor: 8 bit parallel
Max. memory: 65,000 words (all directl addressable)
Instruction cycle time: 2 µs (min.)
Inputs and outputs: 256 (all directly addressable)
Number of basic machine instructions: 78 (181 with variants)
Add/substract time: 2 µs
Number of subroutine levels: 65,000
Interrupt structure: 8 hardwire vectored levels plus software levels
Number of auxiliary registers: 8 plus stack pointer, program counter and accumulator
Memory type: semiconductor (dynamic or static RAM, ROM, PROM)
Memory access time: 850 ns static RAM; 420 or 150 ns dynamic Ram

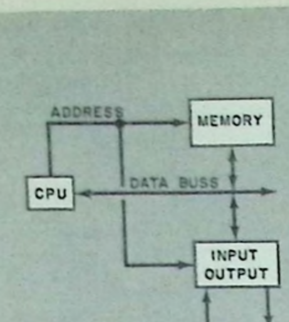

Fig. 1. Basic block diagram of computer parts and operation.

119

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In an upcoming issue, we will describe how to build a low-cost CRT-type terminal that can be used with the computer and can also be mated with any time-sharing computer by telephone.

About the Computer. A computer is basically a piece of variable hardware. By changing the bit pattern stored in the memory, the hardware (electronic circuitry) can be altered from one type of device to another. When the bit pattern, and thus the hardware, is changed, we have what is referred to as "software." Any type of variable instruction (programming)—such as Basic, Fortran, Cobol, Algol—is generally classified as software.

To cause it to vary the hardware, you must communicate with the computer. In the case of the 8800, this is done by setting the bit pattern on the front-panel switches in accordance with a set of instructions (provided with the Intel 8080 LSI chip). For example, the 8800 computer will automatically add when a specific bit pattern (10000010) is received. By setting address and data switches, a complete program of up to 78 steps in the basic computer can be inserted into the processor. If extensive programming is to be performed, an assembler or higher language is used. With an assembler, the person doing the program simply types the word "add" on the device. (In Basic and Fortran, a + is used instead.)

Fundamental programming concepts are simple enough to master in a relatively short time. However, to become an efficient programmer requires a lot of experience and a large amount of creativity.

The block diagram of the basic 8800 computer (or any computer, for that matter) is shown in Fig. 1. It consists of the following subsystems:

CPU. The heart of the computer is the CPU, or central processor unit. See fig. 2. The CPU performs all the calculations, generates system timing, and makes all decisions. Of particular importance are the decisions the CPU makes concerning what device should have access to the data buss. It makes these decisions by sending status information at the beginning of each computer cycle, telling the memory and the input/output what to expect for the rest of the cycle.

The CPU contains the program timer, sometimes called the P counter. This device keeps track of the current location in the memory that the processor is using. Also located in the CPU is the arithmetic unit.

The CPU used in the 8800 computer, the Intel 8080 LSI chip, is relatively expensive in quantities of one. It was selected, however, because it serves to create a minicomputer whose performance competes with current commercial minicomputers. In practice, a lower-performance processor would have been adequate for the majority of the tasks the user might wish to initially define. But the problem with the lesser-power approach is that relatively little money would be saved, and it would be doomed to near-future obsolescence for practical purposes. Our intent here was to produce a processor with more than enough power to handle any job.

Still another consideration was programming. The larger the instruction set, the easier the computer is to program. The 8080 chip has 78 instructions, which is almost twice that of the next power level CPU available (Intel's 8008), which is really designed for use as a buffer.

The CPU contains eight general-purpose registers, P counter, arithmetic unit, accumulator, stack pointer, instruction decoder, and miscellaneous timing and control circuits. The arithmetic unit is of special interest because it contains the circuitry required to perform arithmetic in both decimal and binary formats.

The stack pointer is the register that keeps track of the subroutine addresses. The 8800 computer is capable of performing an almost unlimited number of subroutines, a feature not available with other microprocessors and absent in many minicomputers.

The instruction decoder is the core of the variable-hardware concept. It

PARTS LIST

C1, C5 to C13—0.1-µF disc capacitor
C2—0.01-µF disc capacitor
C3, C4—100-pF disc capacitor
C14 to C20—0.001-µF disc capacitor
IC1—8080 central processing unit IC (Intel)
IC2 to IC5—74L74 IC
IC6 to IC14—8T97 IC
IC15, IC17—7402 IC
IC16, IC32, IC33—7404 IC
IC18 to IC20, IC51—74123 IC
IC21—7473 IC
IC22 to IC24, IC50—7400 IC
IC25—7430 IC
IC26—7410 IC
IC27 to IC31, IC39 to IC41—7405 IC
IC34, IC35—8111 IC
IC36—74L30 IC
IC42 to IC49—74L00 IC
IC52—7406 IC
IC53 to IC58—8111 IC (optional)
LED1 to LED36—Panel-type, red light-emitting diode
(Note: Following are resistors ½-watt, 10% tolerance)
R1, R3, R9 to R31, R56—1000 ohm
R2, R4, R7, R8—330 ohm
R5, R33 to R37—2200 ohm
R6—7500 ohm
R32—100 ohm
R38, R48 to R55—10,000 ohm
R39—200,000 ohm
R40 to R47—470 ohm
R57 to R92—220 ohm
S1 to S16, S25—Spst miniature toggle switch
S17 to S24—Spdt spring-loaded, momentary-action miniature toggle switch
XTAL—2-MHz crystal
Misc.—Metal case; power supply (see text); line cord; multiconductor ribbon cable; mounting hardware; solder; etc.

Note: The following items are available from MITS, Inc., 6328 Linn N.E., Albuquerque, NM 87108 (Tel.: 505-265-7553): partial kit No. 8800PK (includes pc boards and all electronic components (but not case, switches, or power supply), $298; complete kit No. 8800K (contains all parts, including ready-to-use case, switches, and power supply), $397; Completely assembled and tested Model 8800A computer (includes 90-day warranty), $498. Prices do not include postage or delivery charge. Both kits include detailed assembly and operating manual. A FREE set of etching and drilling guides, component-placement diagrams and miscellaneous information is available from the kit supplier (send self-addressed 8½" × 11" envelope with 40c postage). Check supplier or manufacturer for latest IC1 price, available separately.

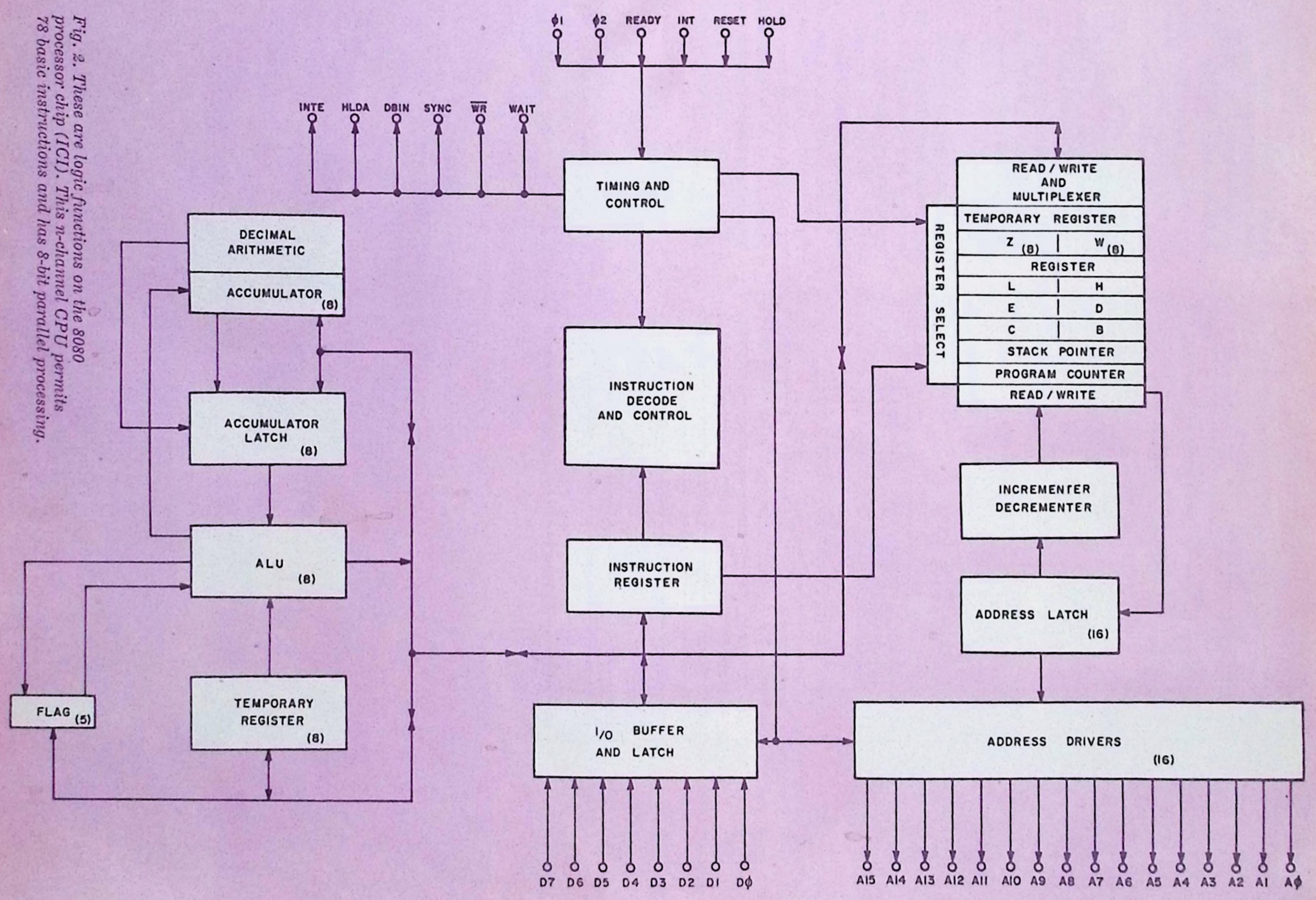

ϕ1
ϕ2
READY
INT
RESET
HOLD
INTE
HLDA
DBIN
SYNC
$\overline{WR}$
WAIT
TIMING AND CONTROL
READ / WRITE AND MULTIPLEXER
TEMPORARY REGISTER
Z (8)
W (8)
REGISTER
L
H
E
D
C
B
STACK POINTER
PROGRAM COUNTER
READ / WRITE
REGISTER SELECT
DECIMAL ARITHMETIC
ACCUMULATOR (8)
ACCUMULATOR LATCH (8)
INSTRUCTION DECODE AND CONTROL
INCREMENTER DECREMENTER
ALU (8)
INSTRUCTION REGISTER
ADDRESS LATCH (16)
FLAG (5)
TEMPORARY REGISTER (8)
I/O BUFFER AND LATCH
ADDRESS DRIVERS (16)
D7
D6
D5
D4
D3
D2
D1
D0
A15
A14
A13
A12
A11
A10
A9
A8
A7
A6
A5
A4
A3
A2
A1
A0

Fig. 2. These are logic functions on the 8080 processor chip (ICI). This n-channel CPU permits 78 basic instructions and has 8-bit parallel processing.

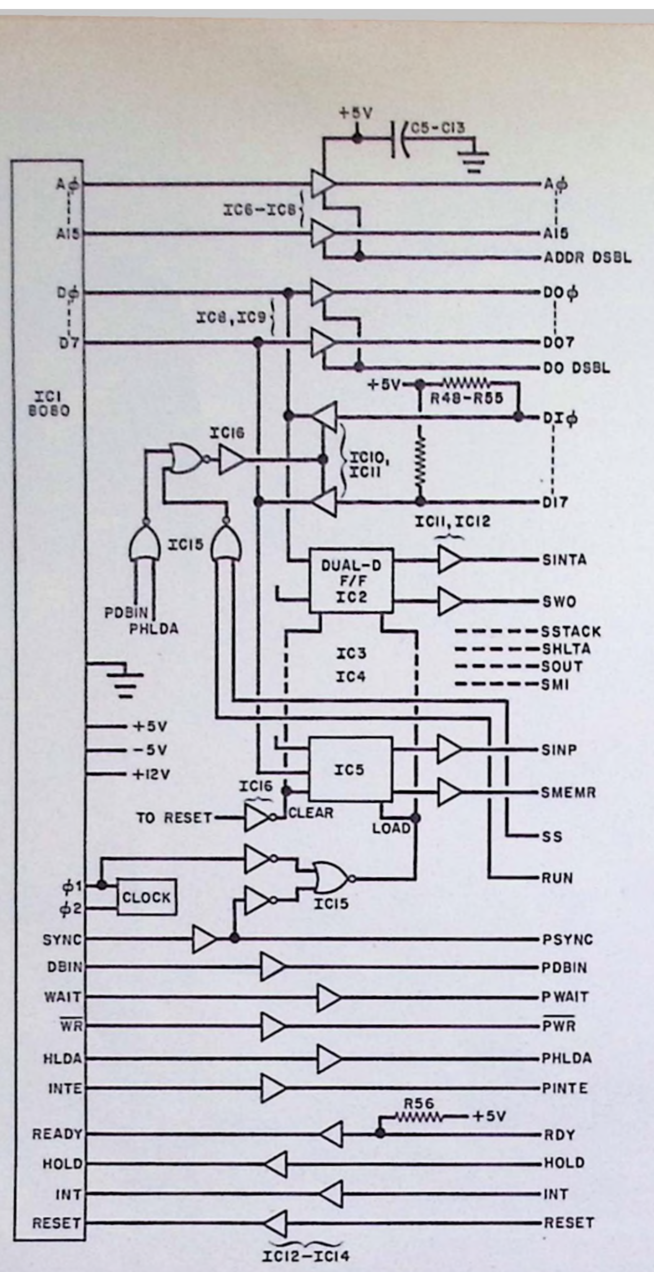
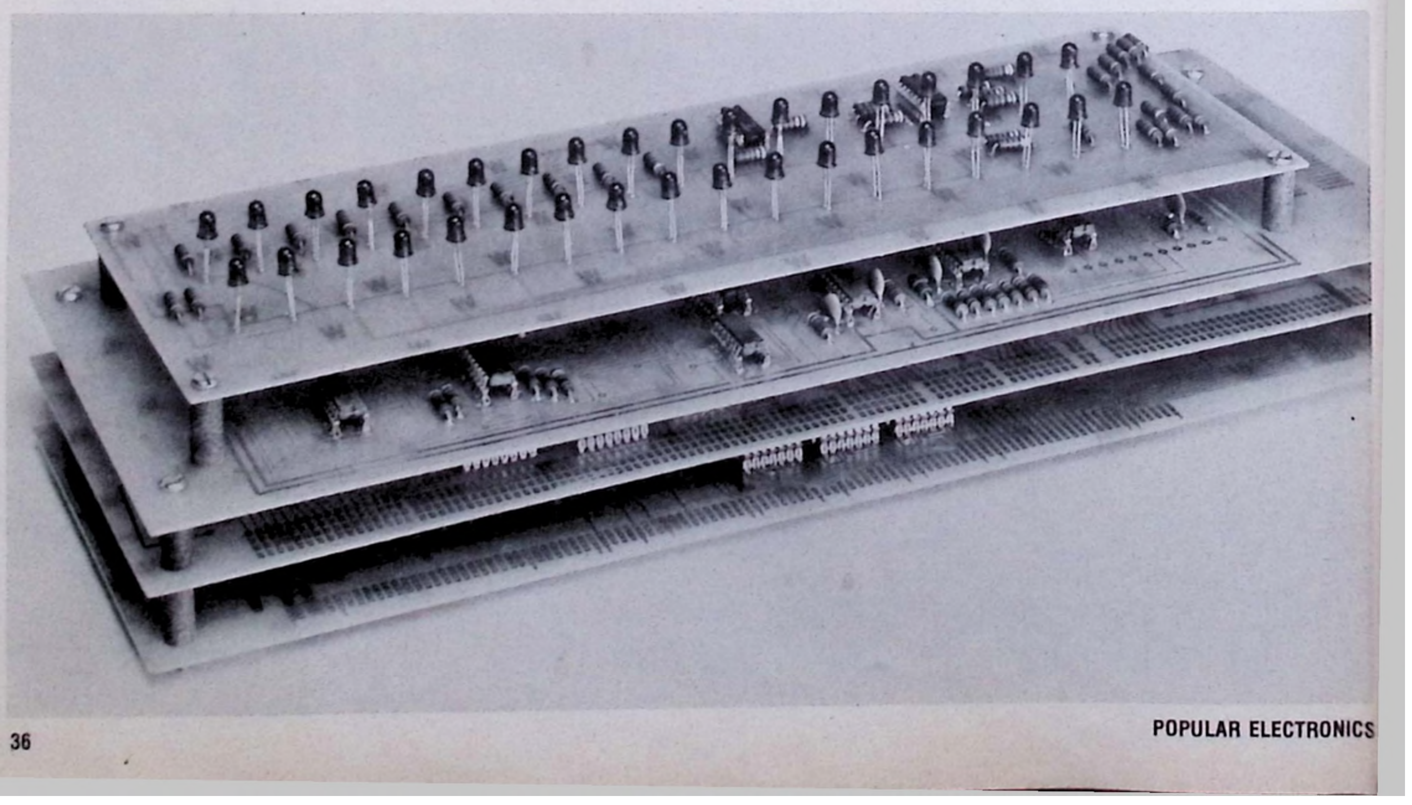

+5V
C5-C13
Aϕ
A15
IC6-IC8
ADDR DSBL
Dϕ
D7
IC8, IC9
DOϕ
DO7
DO DSBL
+5V
R48-R55
DIϕ
DI7
IC1
8080
IC16
IC10,
IC11
IC11, IC12
IC15
PDBIN
PHLDA
DUAL-D
F/F
IC2
SINTA
SWO
IC3
IC4
SSTACK
SHLTA
SOUT
SMI
+5V
-5V
+12V
IC5
SINP
SMEMR
IC16
TO RESET
CLEAR
LOAD
SS
RUN
ϕ1
ϕ2
CLOCK
IC15
SYNC
PSYNC
DBIN
PDBIN
WAIT
PWAIT
$\overline{WR}$
$\overline{PWR}$
HLDA
PHLDA
INTE
PINTE
R56
+5V
READY
RDY
HOLD
HOLD
INT
INT
RESET
RESET
IC12-IC14

Fig. 3. The logic associated with the CPU (IC1) is shown at left. All of the buffers and latches are on a single pc board. Connecting wiring is through a 100-line buss.

decodes the instructions and sets up the various registers, gates, etc., in the CPU for proper functioning. All system timing comes from the CPU. (The logic associated with the CPU is shown in Fig. 3, while the system clock is shown in Fig. 4.)

Memory. A computer memory stores the various binary 0's and 1's that make up its language. These 0's and 1's are known as *bits*. Some memories are organized to store 4, 16, 24, or 32 bits to a *word*, while others—specifically those in the 8800 computer—are organized to store eight bits to a word. Each time the CPU requests data from the memory, a complete word is transmitted. The term *byte* is interchangeable with the

Printed circuit boards are designed so that the various mating pads are aligned. Multi-conductor ribbon cable interconnects the boards.



term word in an 8-bit processor. (The basic 8800 memory is shown in Fig 5.)

The time required from when the address first appears until the data is stable is called "access time." In most modern semiconductor-memory minicomputers, it ranges from 15 ns to 30 µs. With proper adjustments, any memory speed can be used in the 8800 computer, although standard memory time is 850 ns for a static random-access memory (RAM) and 420 ns for a dynamic RAM. Higher-speed memories will not appreciably affect the performance of the computer, while slower-speed memories will result in an overall reduction in system speed.

In addition to semiconductor RAM's, the processor will also service ROM's (read-only-memories) and PROM's (programmable read-only memories). Access time should be reinforced for the particular memory used.

Any conventional memory can be used in the computer if the input loading on the buss does not exceed 50 TTL loads and if the buss is driven by standard TTL loads. Normal expansion loads to the buss would be one standard low-power load per expansion card.

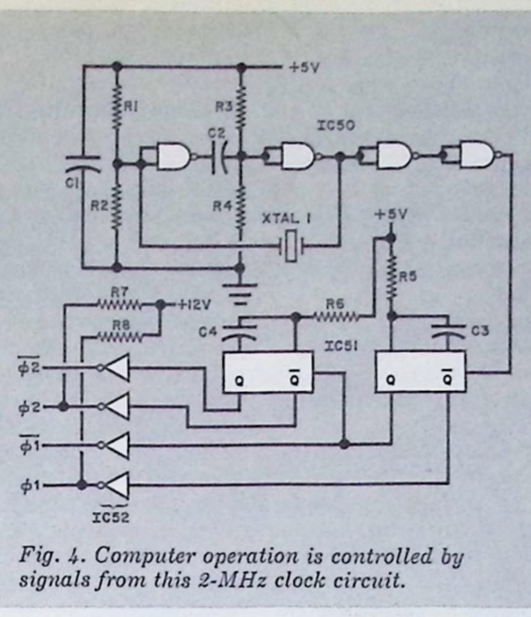

+5V
R1
R3
C2
IC50
C1
R2
R4
XTAL 1
+5V
R5
R7
+12V
R8
R6
C4
IC51
C3
Q
Q̄
Q
Q̄
φ̄2
φ2
φ̄1
φ1
IC52

Fig. 4. Computer operation is controlled by signals from this 2-MHz clock circuit.

Front Panel. The front-panel logic permits the following functions:

1. STOP: Stops the processor immediately after it completes the current instruction. An automatic stop occurs when power is turned on (interrupts are disabled).

2. RUN: Starts the processor at the current address.

3. EXAMINE: Causes the data stored at the location (set by the switches) to

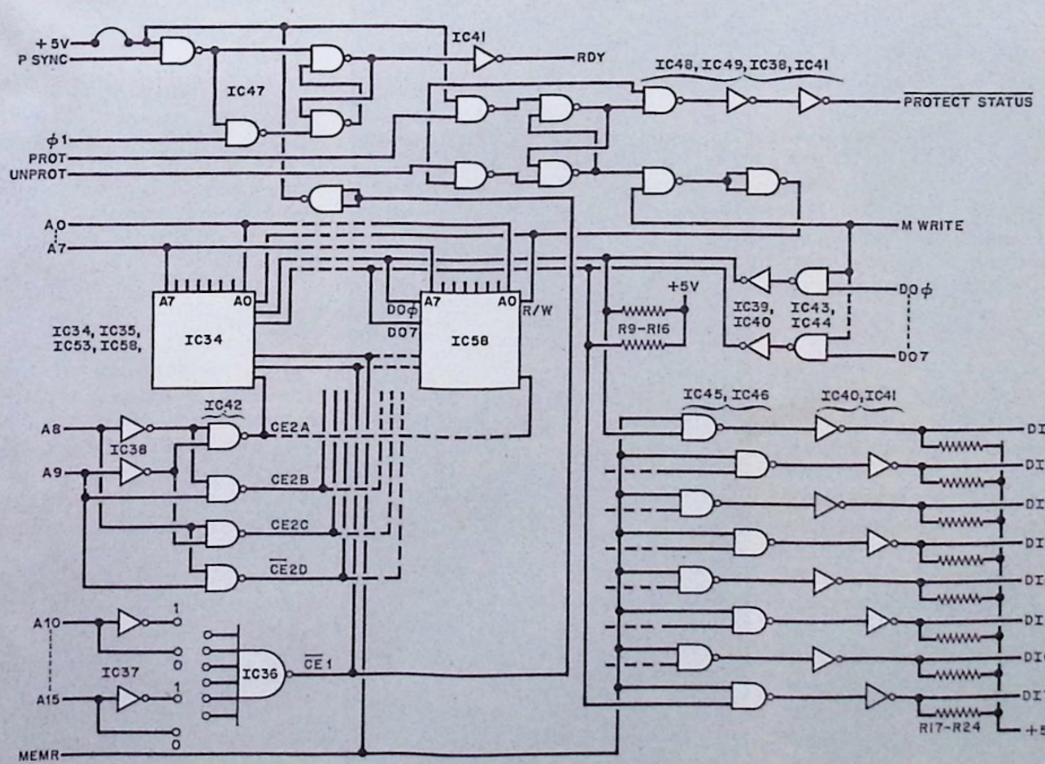

+5V
P SYNC
IC47
φ1
PROT
UNPROT
IC41
RDY
IC48, IC49, IC38, IC41
PROTECT STATUS
M WRITE
A0
A7
A7
A0
IC34
IC34, IC35, IC53, IC58,
DOφ
DO7
A7
A0
IC58
R/W
+5V
R9-R16
IC39, IC40
IC43, IC44
DOφ
DO7
A8
A9
IC38
IC42
CE2A
CE2B
CE2C
CE2D
IC45, IC46
IC40, IC41
DI0
DI1
DI2
DI3
DI4
DI5
DI6
DI7
R17-R24
+5V
A10
A15
IC37
1
0
1
0
IC36
CE1
MEMR

Fig. 5. The basic memory contains up to eight 256 x 4 RAM's.

be displayed in binary by LED's.

4. EXAMINE NEXT: Steps the P counter once and displays the word stored at the next location.

5. DEPOSIT: Causes the information preset by the switches to be stored in the memory.

6. DEPOSIT NEXT: Stops the P counter and loads the memory.

7. SINGLE STEP: Steps the program one instruction.

8. RESET: Clears the CPU and sets up a starting address of 0.

9. CLEAR EXT: Clears all input/ output devices; occurs automatically when power is turned on.

10. PROTECT/UNPROTECT: Allows selective protection/unprotection of blocks of memory. When a block of memory is protected, it is impossible to write over that block, but its contents can be read out.

There are 36 LED status indicators on the front panel, 16 of which are used for the address buss, 8 for the system status latches, and 8 for the data buss. The four remaining LED's are used for indicating memory-protect, interrupt, system-wait, and hold status.

Power Supply. Four power sources are required to operate the computer: +5 volts at 2 amperes, −5 volts at 500 mA, −12 volts at 500 mA, and +8 volts at 6 amperes. The first three are regulated, while the last is unregulated. The three regulated lines power the processor. The unregulated line powers the peripheral cards that can be used to expand the system, each of which has its own 5-volt regulator on board. This reduces electrical noise and obviates the possibility of total system failure due to the failure of only one regulator.

Expansion. The basic computer is designed for almost unlimited peripheral and memory expansion, using a buss system where all input/output connections merge into a common line. Hence, an external card can be plugged into any slot and it will function properly. The only qualification is that each card have an address decoder to allow the specific card to take what data it needs from the common buss and put data on the buss as required. The processor buffers are designed to drive 300 external cards, which should be adequate for most applications. Bear in mind that only 17 cards will yield 65,000 words of memory.

[Editor's Note: At this writing, a number of different peripheral devices are in various stages of design or undergoing tests]

Assembly Details. The basic computer employs four printed circuit board assemblies, each of which contains one functional element of the basic system. Because the boards are large and very complex, we are not publishing etching and drilling guides or component-placement diagrams. Instead, you can obtain a set of guides, diagrams, an instruction set, buss points, and miscellaneous information by sending a stamped self-addressed 8½" ×11" manila envelope wlth 40c postage to MITS, Inc. (See note below Parts List for address.) Request the PE8800 package.

The front panel display board accommodates the 36 LED indicators and their associated drivers. Address line inputs *A0* through *A16*, data lines *D0* through *D7*, and the various status lines originate on the CPU board. The boards have been designed so that the various mating pads on both are aligned. Multi-conductor flexible ribbon cable interconnects the boards.

SOME APPLICATIONS FOR THE ALTAIR 8800 COMPUTER

Listed below is only a small sampling of the thousands of possible applications for the computer. The Altair 8800 is so powerful, in fact, that many of these applications can be performed simultaneously. It can be used as a:

- Programmable scientific calculator
- Multichannel data acquisition system
- Automatic control for ham station
- Sophisticated intrusion alarm system with multiple combination locks
- Automatic IC tester
- Machine controller
- Digital clock with all time-zone conversion
- High-speed I/0 device for large computer
- Digital signal generator
- Automated automobile test analyzer
- On-board mobile controller
- Autopilot for planes, boats, etc.
- Navigation computer
- Time-share computer system
- "Smart" computer terminal
- Brain for a robot
- Pattern-recognition device
- Printed matter-to-Braille converter for the blind
- Automatic drafting machine
- Automatic controller for heat, air conditioning, dehumidifying
- Controller for sound systems
- Digital filter
- Signal analyzer

The front panel control board contains the circuitry for the interfacing between the control switches located on the front panel and the CPU. In addition to the interconnections to the actual processor, this board accepts memory address switches *A0* through *A15* (also on the front panel). The first eight of these switches (*D0* to D7) are used to put data into the CPU. The EXAMINE/EXAMINE NEXT, DEPOSIT/DEPOSIT NEXT, SINGLE STEP, and RUN/STOP switches are also wired directly to the front panel control board.

The third board contains the Intel 8080 central processing unit LSI chip, two-phase clock and buffers, and the various lines going to the buss. (The buffers are tri-state, high-input-impedance, high-output-level devices.) This board also has four dual-D flip-flops wired as latches for the eight bits of status information. All input and output wiring to and from the CPU board is via a 100-line buss.

The basic memory board contains 256 eight-bit words of random access memory (RAM). It is directly expandable to 1000 words. This board also contains the input/output data-gating, address-decoding, memory-wait, and memory-protect circuits. The memory-wait circuit allows the memory time to stabilize the output data to the processor, while the memory-protect circuit prevents accidental overwriting of the memory. All connections between the CPU and the memory board are via the 100-line buss.

The four boards, along with the power supply, mount in an 18-in. deep by 17-in. wide by 7-in. high (45.7 × 43.2 × 17.7-cm) metal cabinet. The various operating switches and LED indicators go on the front panel. When all this is done, the computer cabinet's interior will appear to be almost empty. However, the internal cabling system is arranged with connectors to accommodate 17 more boards within the case, all connected to the main buss lines. The added boards can be used for memory, input/output devices, control devices, etc. All you have to do is plug the boards into the connectors and the computer does the rest.

Part 2 of this article, next month, will describe the operation of the computer and present some sample programs.

◆

BY MICHELE FRAN

Thyristor Circuitry for ELECTRONIC Photoflashers

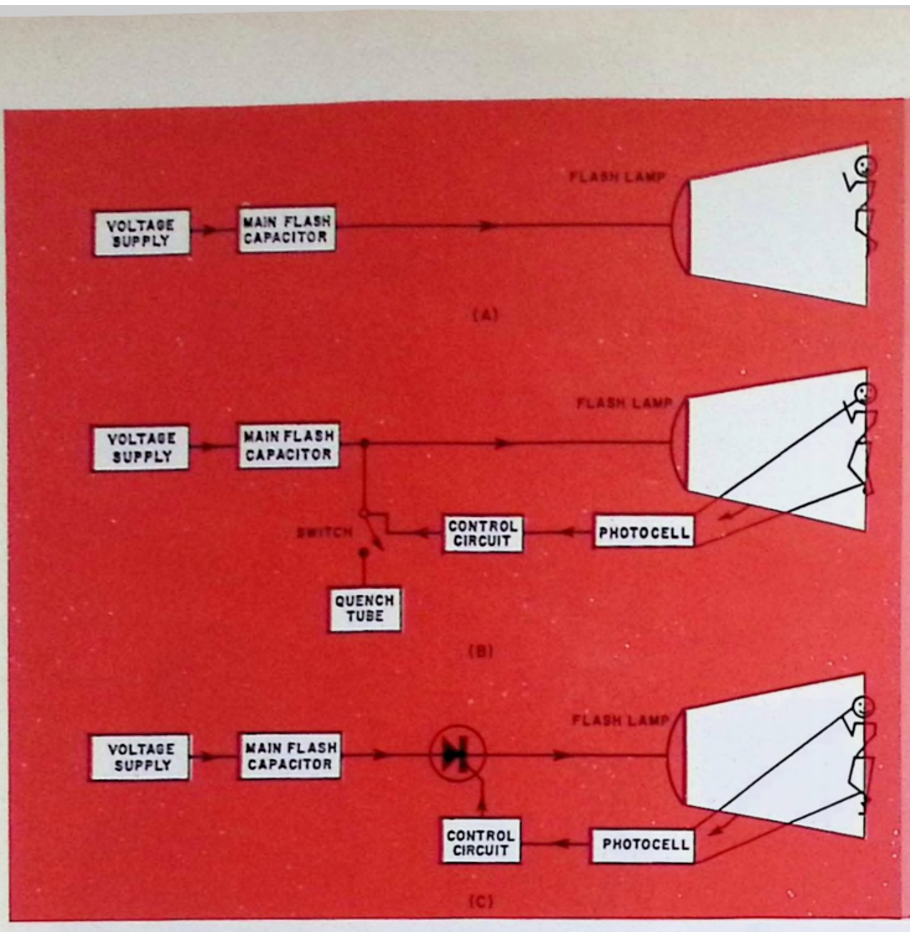
How a simple SCR trigger provides faster recycling, more flashes per charge and quick recharge for the latest breed of automatic electronic flashers

THE ELECTRONIC flash system brought "stop action" photo opportunities to camera enthusiasts. It also eliminated the need for changing spent flashbulbs thanks to the storage properties of the electrolytic capacitor and the use of long-life gaseous lamps. The next major advance in electronic flash technology can be pinpointed to 1965 when Honeywell Photographic introduced an automatic electronic flash, freeing photobuffs from having to set f-stops for each shot that was at a different distance.

Now electronics has created another plateau in automatic flash technology by adding thyristor control—an SCR that both triggers the flash and stops capacitor discharge when the subject receives sufficient light. The result? More flashes per battery charge, faster recycling time for the next shot, and short recharge time.

A Flash of Light. For background, here are the various steps that go into producing the electronic flash of light. First, voltage from a battery, the usual power source in an electronic flash, is converted to ac by means of an oscillator circuit. (This oscillator, by the way, is what causes the characteristic "whine" you hear in the electronic flash unit.) Once the ac is generated, it is stepped up to a higher voltage by a transformer. Then the ac is converted back to dc by a rectifier, after which it is stored in the flash unit's main electrolytic capacitor. (Capacitors in modern flash units are capable of storing potentials of about 350 volts.) The flash capacitor is connected to a gas-filled tube. Xenon is the usual gas used, although some other types are available.

minolta
minolta
XK
MC ROKKOR-X PG 1:1.4 f=50mm
JAPAN
3700120

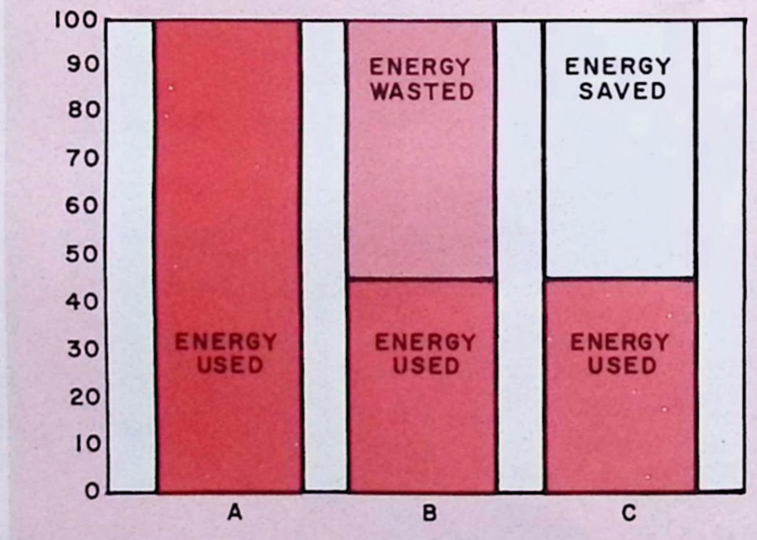


Three greatly simplified block diagrams show the major components of the various types of electronic flashers. At (A), a manual unit is the least complex. Diagram (B) shows how a photocell is added with control circuit and quench tube to dump surplus energy. At (C), a thyristor unit adds an SCR to trap voltage from the main flash capacitor.

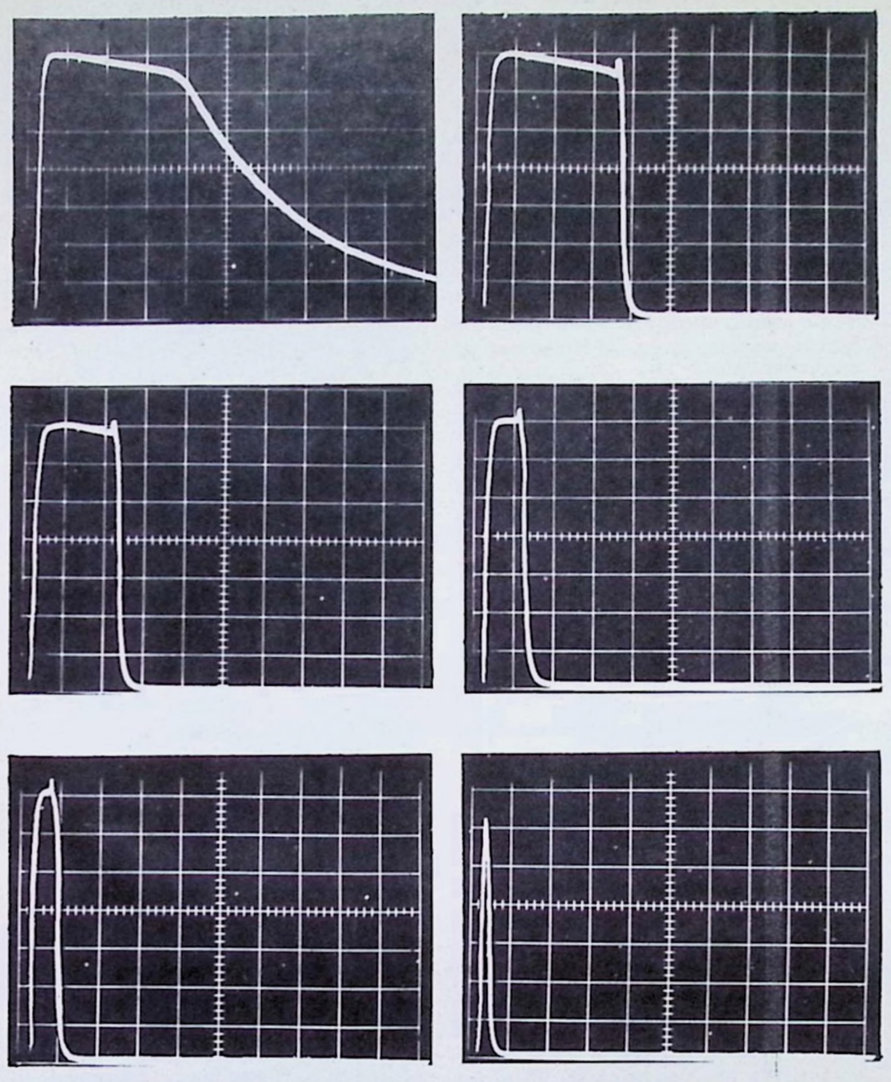
At this stage, everything is set for triggering the flash. What is now needed is a high-voltage pulse to ionize the gas in the flashtube to make it conductive so that energy can flow through the tube, where it will be converted to light. This high-voltage pulse is created as the camera's shutter contacts close, causing a small trigger capacitor to release its charge into a spark coil connected to the wall of the flashtube. After the charge on the flash capacitor has been exhausted, the gas becomes de-ionized and no longer conductive. The recharging cycle can then begin. Once the cycle is complete, as indicated by the ready lamp on the flash unit, the flash can again be fired.

Automatic Flash. Film exposure is based on two factors: time and intensity. With the pre-1965 photoflashers, the time factor (flash duration) was fixed at about 1/1000 of a second for most units. Hence, intensity had to be controlled by changing the camera's lens opening (f-stop).

The Honeywell 660 automatic flash employed the first "quench circuit" and operated on the variable of time. Now, instead of just one flash duration of perhaps 1/1000 second, the flash unit would give a burst of light with a duration of anywhere between,

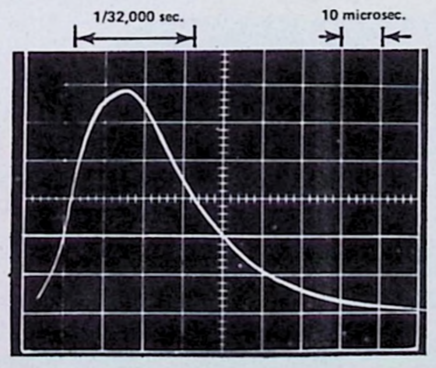


Energy used by three electronic flash units shooting the same scene. At (A), the manual unit uses all the voltage stored in flash capacitor to illuminate the scene. Proper exposure is obtained by setting the f-stop on the camera. In unit (B), a quench-tube type, exposure was controlled by the flash unit. Only 45 percent of the energy was used to expose the film. Flash unit (C) used the same amount of time and energy as (B) to illuminate the subject properly but unused energy remained in the flash capacitor, resulting in less battery drain as well as a faster recycling time between shots.



TRACES FROM AN ENERGY-SAVING FLASH UNIT

Oscilloscope traces show results of synthesizing various working distances by regulating a set of baffles in front of a Braun 2000 flash unit, then measuring the resulting flash waveform with a photomultiplier and scope set to 0.2 ms per division. Effective flash duration varies from maximum of 1/1000 s (equivalent to using unit on manual or at its maximum working distance) to minimum of 1/32,000 s (using unit at closest working distance). Peak in the waveform on middle four traces is from firing of the flash tube. This is a characteristic of some, but not all, of latest energy-saving flash units using thyristors.



We used a high-speed oscilloscope to check flash duration of the Braun 2000, set to give briefest flash of 1/32,000 s. Measurement from pulse width at half height.

1/1000 and 1/30,000 second. The exposure control was taken from the camera, and the photographer put in the flash unit. The photographer had only to set an f-stop on his camera, following the recommendations of the manufacturer based on the light intensity from the flash unit and the ASA of the film. The flash unit would then control the duration of the light.

Here's how it works. Light emanating from the flash tube is reflected from the subject back to the flash unit, where it is detected by a photocell. The photocell is connected to a small timing capacitor whose value has been carefully selected based on known criteria (f-stop to be used with a given ASA of film, light intensity, and distance) that add up to an exposure analog. The amount of light falling on the photocell can be biased either by using small apertures or neutral-density filters placed before it. By so doing, the photocell can be fooled into believing that it takes two, three, or four times as long to illuminate the scene. Responding to the amount of light falling on it, the photocell regulates the charging of the timing capacitor. Once the timing capacitor has reached its full charge in a quench-tube circuit, it closes another switch that allows the current flowing from the flash capacitor to be shunted to another tube, with a lower series resistance. Here, the energy is expended in the form of light and heat.

This second tube is never seen by the photographer, and its light never plays a part in the photographic process. It is just a convenient way of dumping the unneeded energy flowing from the flash capacitor. With this approach, flash durations of up to 1/70,000 second have been obtained with small electronic flash units, permitting us to record such things as bullets piercing wood, balloons breaking, etc.

All of this was enough to send most photographers into fits of ecstasy, but it still left one problem. Even though the quench-tube idea brought enormous flexibility to electronic flash units, they were still energy wasters. There was no feasible way to dam up the energy flowing from the flash capacitor to the flash tube. The result was that a photographer could obtain only a limited number of flashes per battery or charge. In the case of the rechargeable nickel-cadmium battery, this was usually about 40 to 60 flashes.

Enter Thyristor Control. In the fall of 1972, Braun introduced the first series-circuit, thyristor-controlled flash units. The much-sought-after breakthrough came in the form of a small silicon controlled rectifier (SCR) called a "thyristor." Operating as an electronic switch, this little solid-state wonder can handle the load flowing from the flash capacitor and stop it at the precise moment that the exposure control circuit says the subject has received enough light. Instead of having a parallel circuit that simply reroutes the energy from the flash capacitor, we now have a series circuit that allows the leftover energy to remain in the flash capacitor.

The thyristor has many advantages, among them: It can switch on and remain on until the current flowing through a dc circuit drops to zero (or near zero). It can be made to open if it receives a very brief low-energy pulse from the opposite direction. The pulse to shut down, of course, comes from the timing circuit with its small capacitor connected to the photocell.

Used in an electronic flash unit, the thyristor performs two jobs. First, it stops the current flowing from the main flash capacitor, thus regulating the duration of the flash in the same manner the parallel quench circuit did. And it allows the unused energy to remain in the flash capacitor, rather than being wasted. This, in turn, provides another advantage. Recycling times can be shortened because the battery can very quickly supply the small amount of energy necessary to recharge the capacitor. Battery power can be conserved —meaning more flashes per charge.

One series-type thyristor flash unit known to us recycles in about 2.5 seconds after illuminating a scene 10 ft (3.05 m) away. In doing so, it uses only 22 percent of the energy in the flash capacitor. However, if this same unit is fired at a subject 20 ft (6.1 m) away, it will have used up 90 percent of the stored energy and will require 6 seconds to recharge. At distances of 2.5 ft (0.76 m), the recycling time would be only about 0.25 to 0.33 second. In the manual mode (with the photocell covered), or at distances at the very end of the electronic flash's ability to properly illuminate the scene, the thyristor does not receive the reversing pulse from the timing circuit. Instead, it opens after the voltage in the flash capacitor has dropped to near zero (usually about 1.5 volts).

Battery conservation goes hand in hand with the storage of energy in the flash capacitor. Before the thyristor made its appearance in flash units, it was necessary each time to supply enough power to bring a fully depleted capacitor up to full charge. Now, the thyristor has reduced the requirement so that only fractions of the earlier power are required to recharge a partially discharged capacitor. In some cases, if the flash unit is used exclusively at the closest working distances (where the duration of the flash is briefest), it is not uncommon to obtain 700 to 1000 flashes per nickel-cadmium battery charge. (On manual, these same batteries would deliver only about 60 flashes per charge. Since no one shoots exclusively at distances of 2.5 ft (0.76 m), the more usual number of flashes per charge is about 100 to 200.

Thyristor-controlled electronic flashes are not likely to glut the market in the near future. This type of flash makes sense only with the more high-powered flash units. The low-powered flash units generally require the entire flash charge on the capacitor to illuminate scenes greater than 10 ft (3.05 m) away; so, there would be no energy savings by building into them a thyristor circuit. Only flash units where a small amount of energy would be used in a shot would make the thyristor circuit practical and necessary.

Another thing barring the universal use of the thyristor in electronic photoflash units is that this type of SCR is expensive and can be tricky to make. Quality control must be very tight, which reduces the number of devices available. This means that thyristor suppliers are having a rough time trying to keep up with the demand. Manufacturers tell us that they are having troubles trying to get enough thyristors just to meet the demand for flash units now in production.

When you do see a thyristor-controlled flash unit, you can bet you will have to pay more for it than you are accustomed to do for "conventional" flash units. The type of sophistication built into these flash units does not come cheap. Perhaps when semiconductor manufacturers can crank out this type of SCR the way other manufacturers crank out resistors, a price reduction can be anticipated—but not before then.

Who Makes Them. If you want to look for one of the new thyristor-controlled flash units, ask for any of the following in your local photo store: Argus Model 1272 or Model 1275; Auto Spiralite Thy 1000; Bell & Howell Model 880; Braun Vario Computer 2000 F022 or F027; Honeywell Auto Strobonar 470; Metz Mecablitz 402 or 217; Rollei Model 36 RE or Model 140 RES; or the Vivtar Auto Thyristor Model 292 or Model 352. Canon, Minolta, and Nikon also market this type of electronic photo flash unit outside the U.S. ◆

A state-of-the-art report on charge-coupled devices and scanned photodiode arrays.

BY HARRY GARLAND AND ROGER MELEN

Solid-State Image Sensors— TV Camera Tube Successor?

AN EXPERIMENTAL TV camera has been developed that is no larger than a pack of cigarettes. Equipment is being installed at supermarket checkout counters that can automatically read price tags. There is even a machine that enables blind people to read ordinary printed material. All of these developments are made possible by the use of solid-state image sensors—a special type of integrated circuit.

An image sensor can contain hundreds, even thousands, of individual photosensitive elements on a single chip of silicon. It is normally mounted in a standard IC package that is covered with a transparent top. When a scene strikes the image sensor, usually through a lens as shown in Fig. 1, the individual elements of the sensor can be scanned electronically and their outputs displayed.

Area vs. Image Array. The photosensitive elements of an image sensor can be in either a linear or an area array. In a linear array the elements are in a single line; in an area array, they are in a two-dimensional matrix.

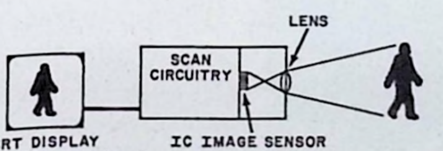


Fig. 1. An image-sensor system.

A linear array can be used to produce a two-dimensional picture, but only one line at a time as the image moves across the sensor. The number of elements in an array determines the resolution of the picture. The effect of resolution on picture quality is shown in Fig. 2. Here, the same picture is scanned by five different linear arrays. The array with the lowest resolution (32 elements) produced the picture at the right, while the picture on the left was produced by an array with 512

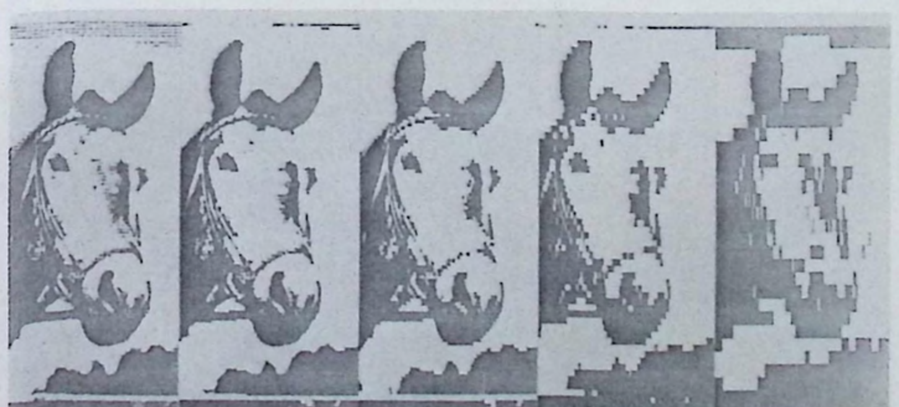


Fig. 2. Photos of displays show how resolution affects picture quality. Number of elements in array increases from right to left.

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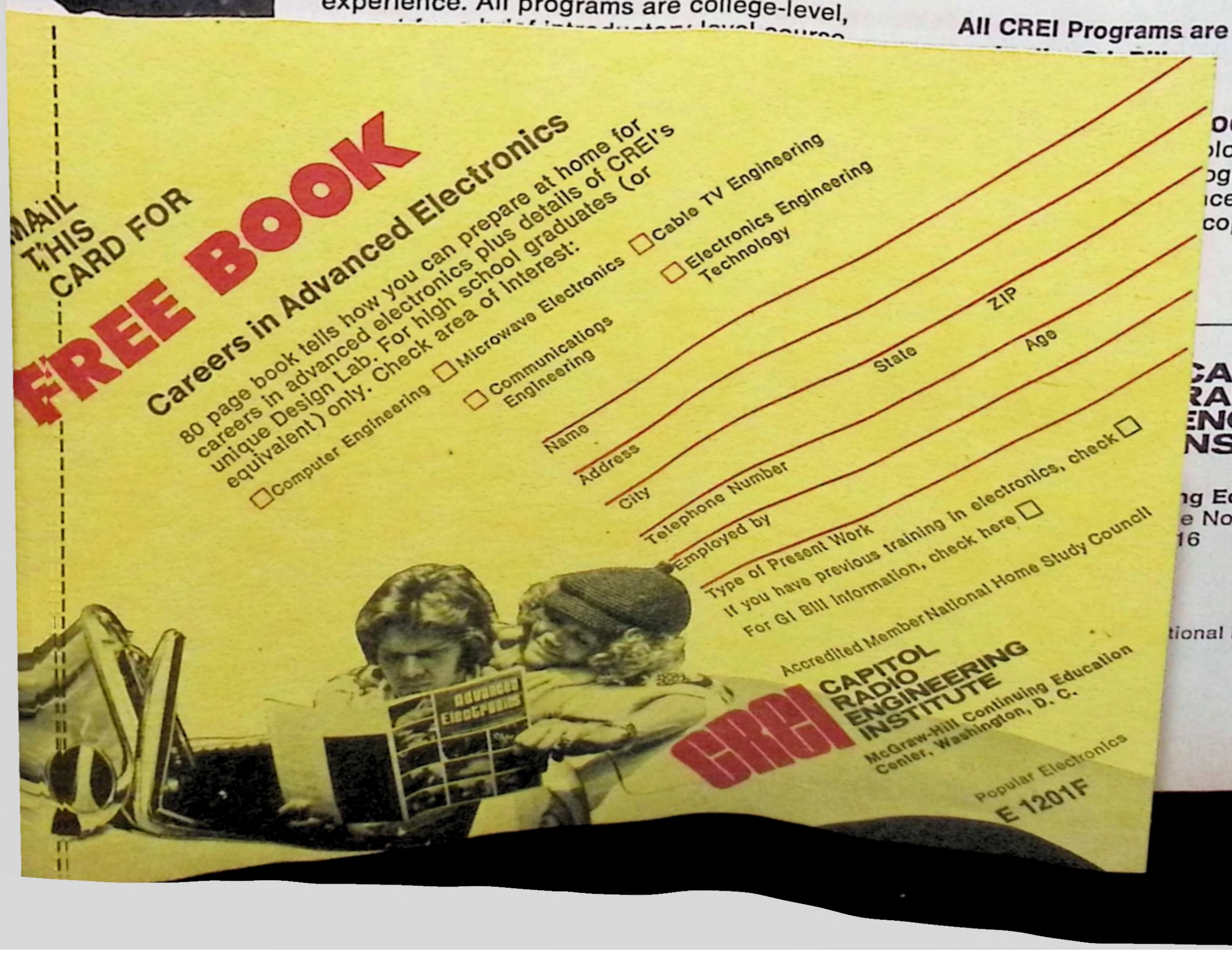

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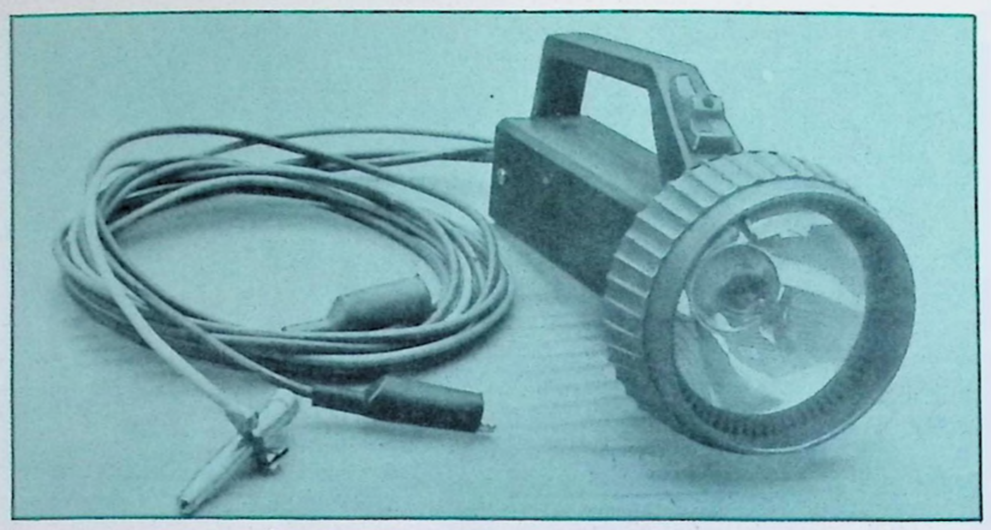
AN IGNITION TIMING LIGHT FOR IMPROVING GAS ECONOMY



BY ANTHONY CARISTI

NOWADAYS, everyone knows how important it is to get the best gas economy possible from an automobile. One of the more important factors that affect economy is engine timing. In addition, proper timing is required on all automobile engines so that exhaust emissions do not exceed allowable limits.

Timing changes for a variety of reasons. As the parts of an engine wear, the timing tends to become retarded. If ignition points are replaced, timing is also disturbed. Furthermore, it is virtually impossible to set the point gap exactly the same as it was when the timing was last set.

Using a dwell meter is a far more accurate method of setting point gap than using a feeler gauge, but even this will not guarantee proper ignition timing. The fact is, the best way to check ignition timing is with a timing light.

The timing light described here can be built for only a few dollars. Yet, it is designed to perform as well as a commercial unit costing $25 or more. Its light output is bright enough to use under conditions of bright daylight, and it is battery-powered (from the car's battery)to make it independent of the ac line.

About the Circuit. The heart of the timing light's circuit (Fig. 1) is dc-to-dc converter transformer *TI*. It alternately switches current between transistors *Q1* and *Q2*, while stepping up the battery potential to about 125 volts. A ferrite pot core was chosen for this circuit to keep down project size and cost.

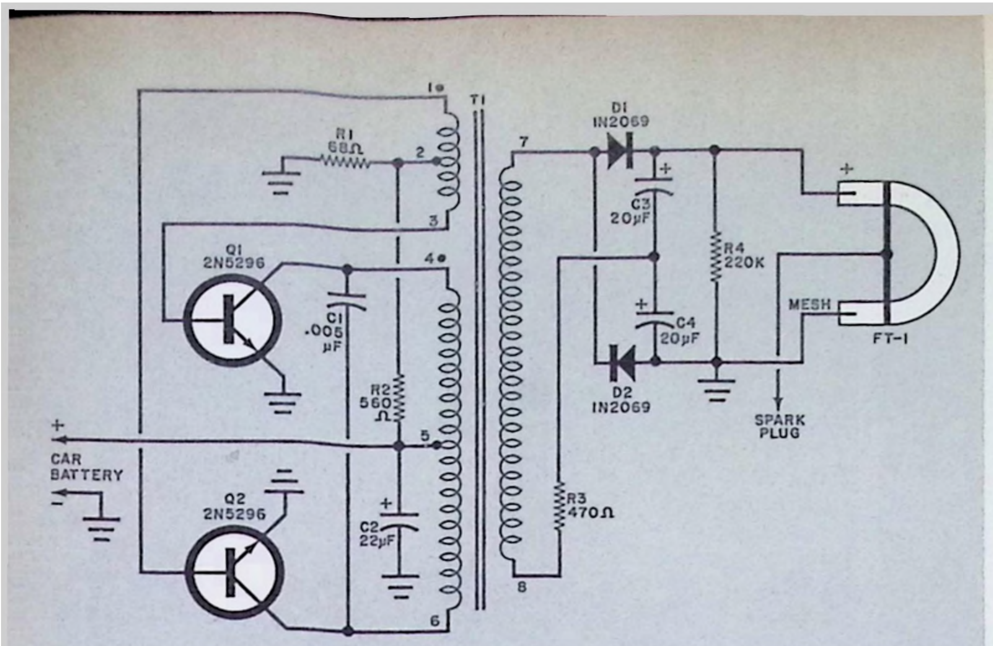
The primary winding of *T1* (wound around the pot core) is done by the "bifilar" method that gives tight coupling and accurately locates the center tap. The tight coupling is essential to keeping the voltage spikes across the transistors to an absolute minimum. (In this type of circuit, the spikes can easily exceed ten times the supply voltage if a poorly designed transformer is used causing transistor failure.) By using a bifilar winding for the primary, the voltage spikes across *Q1* and *Q2* are well below the 60-volt rating of the transistors.

The stepped-up voltage from the secondary of *T1* is again stepped up by the voltage-doubler circuit consisting of *D1* and *D2*. It is then passed into flashtube *FT1*.

Construction. Perhaps the most demanding part of the construction process is the winding of *T1*. Even so, the job is not difficult, only time-consuming. The transformer should be wound in the following manner:

Start by winding the feedback loop (its leads are labelled 1 through 3 in Fig. 1) on the bobbin supplied with the ferrite core. Use No. 30 enameled wire. This winding consists of 10 turns of wire, interrupted at the 5th turn for a center-tap connection. Connect and solder 5-in. (12.7-cm) lengths of stranded hookup wire to the ends and center-tap of the winding. Label the leads 1 at the first turn, 2 at the center-tap, and 3 at the final turn. Then wrap the winding with a layer of thin Mylar or plastic tape.

Next comes the bifilar-wound primary winding . This consists of 27 double turns of No. 30 enameled wire.



PARTS LIST

C1—0.005-μf, 500-volt disc capacitor
C2—22-μf, 25-volt tantalum electrolytic capacitor
C3,C4—20-μf, 150-volt electrolytic capacitor
D1,D2—500-volt, ½-ampere silicon rectifier (1N2070, HEP R0053 or equivalent
FT1—250-volt, 50-watt-second flash-tube (Radio Shack No. 272-1145 or similar)
Q1,Q2—60-volt, 1-ampere npn silicon transistor (2N5296 or equivalent)
R1—68-ohm, ¼-watt resistor
R2—560-ohm, 1-watt resistor
R3—470-ohm, 2-watt resistor
R4—220,000-ohm, ½-watt resistor
T1—Transformer wound on TDK Type H5A P2213 Z52H ferrite core and TDK Type BP 2213-612 bobbin (See text)*
Misc.—Flashlight body (see text); color-coded test lead cables; alligator or crocodile clips with insulated boots (2); rubber grommet; printed circuit board; Dow Corning Silastic® cement; machine hardware; stranded hookup wire; No. 30 and No. 36 enameled wire; spring-type spark plug cable connector (available from most automotive supply outlets); stranded hookup wire; solder; etc.

*The TDK ferrite-core/bobbin assembly is available for $3 from: Anthony Caristi, 69 White Pond Rd., Waldwick, NJ 07473.

Fig. 1. The dc-to-dc converter (TI) steps up the battery voltage.

Label one end of a 4-ft (1.22-m) strand of the enameled wire with a 4. Label one end of a similar strand 5. Starting with these two ends together, wind 27 turns of both wires on the bobbin. Using an ohmmeter, determine the unmarked end of the wire that started with 4 and connect it to the end marked 5. This is the center tap. The other unmarked end is terminal 6. Cover the winding with tape to hold it in place and insulate it from the secondary.

The secondary winding consists of 240 turns of No. 36 enameled wire. This is the most tedious part of assembly. Be sure to accurately count the number of turns as you go. How many turns you wind will determine the dc potential applied to the flash-tube. When you are finished winding, attach 5-in. lengths of stranded hookup wire to the winding ends and label them 7 and 8. Then wrap the turns with tape.

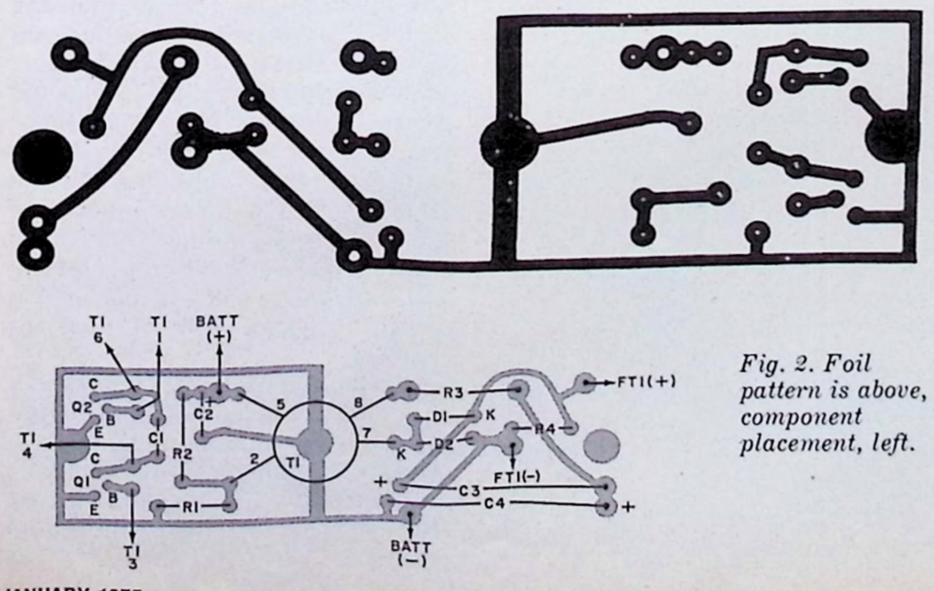


Fig. 2. Foil pattern is above, component placement, left.

Now you can begin assembling the circuit proper. A printed circuit board is recommended for component mounting (see Fig. 2 for actual-size etching and drilling guide and components placement diagram).

Transformer *T1* is mounted on the board with the aid of a 6-32 × 1-in. machine screw, fiber washer, (at the top of the transformer), and a 6-32 nut. Do not overtighten the hardware or you will crack the core, rendering it useless. (Note: Capacitor *C4* mounts on the board atop *C3* as shown in Fig. 3)

When the circuit board assembly is completely wired, temporarily connect to the appropriate points on it red and black hookup wires for the positive and negative battery leads. Connect the leads, properly polarized, to a 12-volt battery or other dc source. If the board and transformer are properly assembled, you should hear a high-pitched tone when power is applied. This is the vibration of the transformer core as the circuit oscillates. A VOM connected across *R4* should provide a 250-volt reading if the input potential to the circuit is set to 14.5 volts. If the circuit does not oscillate, the phasing of the feedback winding of *T1* may be incorrect, in which case, you can transpose leads 1 and 3 and try again. Remove the temporary leads.

The type of flashlight body best suited for your timing light is shown in the lead photo. You will have to drill two mounting holes for the circuit board assembly. A third hole that permits color-coded battery and plug leads to exit the flashlight body should be lined with a rubber grommet. Pass the leads through this hole and connect and solder them to the appropriate points on the board. Terminate the positive and negative battery leads with insulation-booted alligator or crocodile clips and the plug lead with a spring-type plug-to-cable adapter.

Turn over the circuit board and carefully solder a 4-40 machine nut to the copper pads surrounding the mounting holes. Make certain that the nuts are centered over the holes and that no solder flows into the threads.

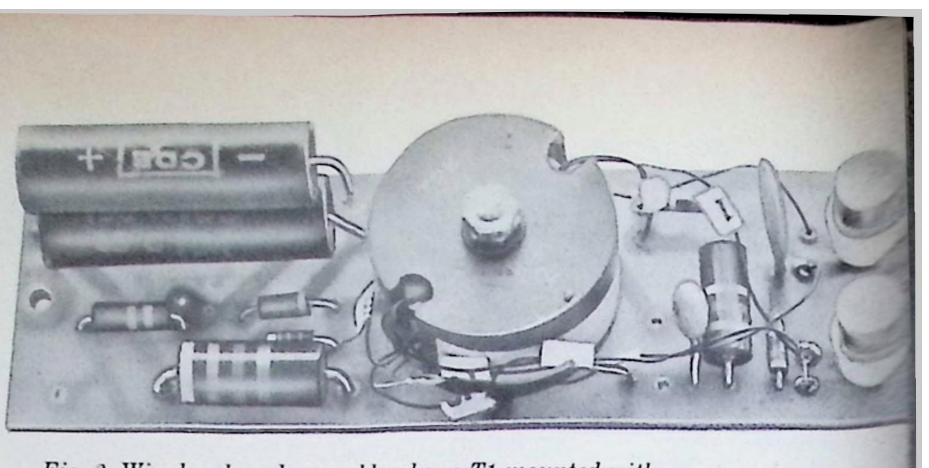


Fig. 3. Wired pc board assembly shows T1 mounted with hardware fiber washer. C4 is on top of C3.

The flashtube mounts in the flashlight's reflector. You can enlarge the standard lamp hole in the reflector with a rat-tail file, working carefully to avoid damaging the reflector or scratching its reflective coating. The flashtube's fit should be reasonably close without binding. Place the reflector assembly face down on a flat surface and insert the flashtube in the enlarged hole, positioning it with its point against the glass lens and vertical to the plane of the lens. Run a bead of epoxy or Dow Corning Silastic® cement between flashtube and reflector and allow the cement to set overnight. Be sure to maintain the flashtube vertical to the lens as the cement sets (Fig. 4).

Once the cement has set, you can complete final assembly. Locate the negative (woven) electrode lead of the flashtube and connect it to the hole marked *FT1*(−) in the component-placement guide in Fig. 2. Then connect the positive electrode lead (it exits the end of the flashtube opposite the negative electrode lead) to the *FT1*(+) point on the board. The only connection left to be made is the spark-plug test lead. Locate this lead and connect and solder it to the high-voltage terminal on the flashtube. (Note: The high-voltage terminal is the metal band affixed to the outside of the flashtube.) Pack the connection with Silastic cement to insulate it and set the assembly aside to harden.

When the cement has set, slide the circuit board assembly into the flashlight case and anchor it in place with two 4-40 × ½-in. machine screws. Screw on the reflector assembly but under no circumstances permit the reflector itself to rotate. If you allow the reflector to rotate, the flashtube will be damaged or a short circuit will develop.

How to Use. Before making any timing adjustment on your car, set the dwell time of the ignition points according to the recommendation of the manufacturer of your car. This can be accomplished by using a dwell meter on most General Motors cars and adjusting the points with an Allen wrench while the engine is running. On other car makes, the dwell angle must be set by adjusting the point gap opening. Bear in mind that the dwell angle must always be properly set *before* the timing is adjusted as changes in the dwell angle will change ignition timing.

Locate the number one cylinder of your car's engine. (On 4- and 6-cylinder engines, it will be the one nearest the front of the engine. The number-one cylinder on a V8 engine is also nearest the front, but it could be either on the left or the right.) With the engine shut off, remove the ignition lead to the number-one cylinder and connect the timing light's plug lead to the plug. Replace the ignition wire.

Before starting the engine, it is advisable to clean the flywheel and paint a thin white line over the timing mark so that it is readily visible. Then refer to the decal, located in the front of the engine compartment of late model cars, to determine the calibration of the timing scale and proper ignition timing specifications.

Remove the rubber hose connected to the vacuum diaphragm of the distributor and plug the hose opening with a pencil. This disables the automatic vacuum advance built into the distributor. Timing of an engine is always adjusted with the vacuum advance disabled. If you neglect to do this, you will set the timing incorrectly and the engine will not operate properly.

Connect the remaining two timing light cables to the car's battery, observing the proper polarity. Start the engine. The light should now be flashing at a rate of 4 to 5 times per second. Aim the timing light at the flywheel to locate the timing mark. The mark should appear to be stationary. If timing is not correct, loosen the bolt that clamps the distributor assembly to the engine and rotate the distributor in the direction that yields the proper indication. Tighten the bolt and recheck the timing to make sure it has not changed.

Stop the engine. Remove the timing light and replace the hose to the distributor's vacuum-advance diaphragm. The timing of the engine is now correctly set. It need not be checked again until the points are replaced. ◆

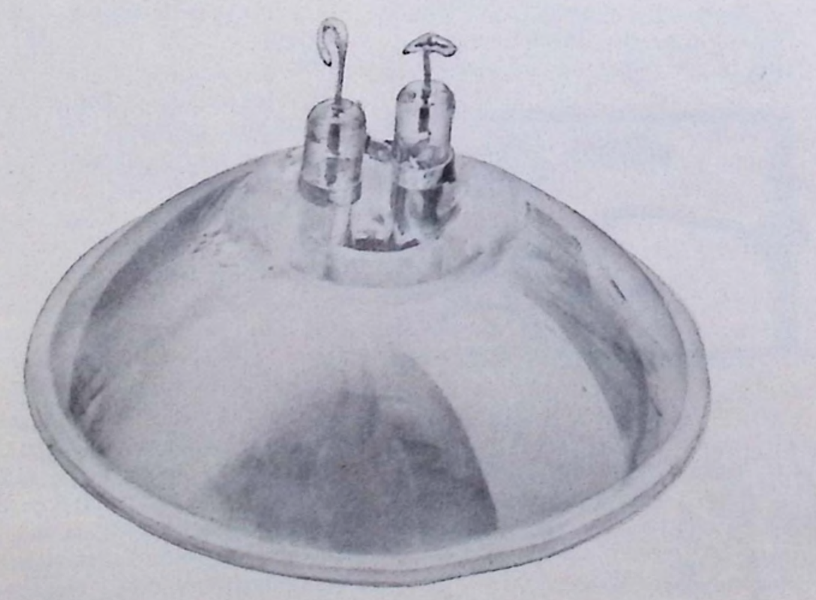
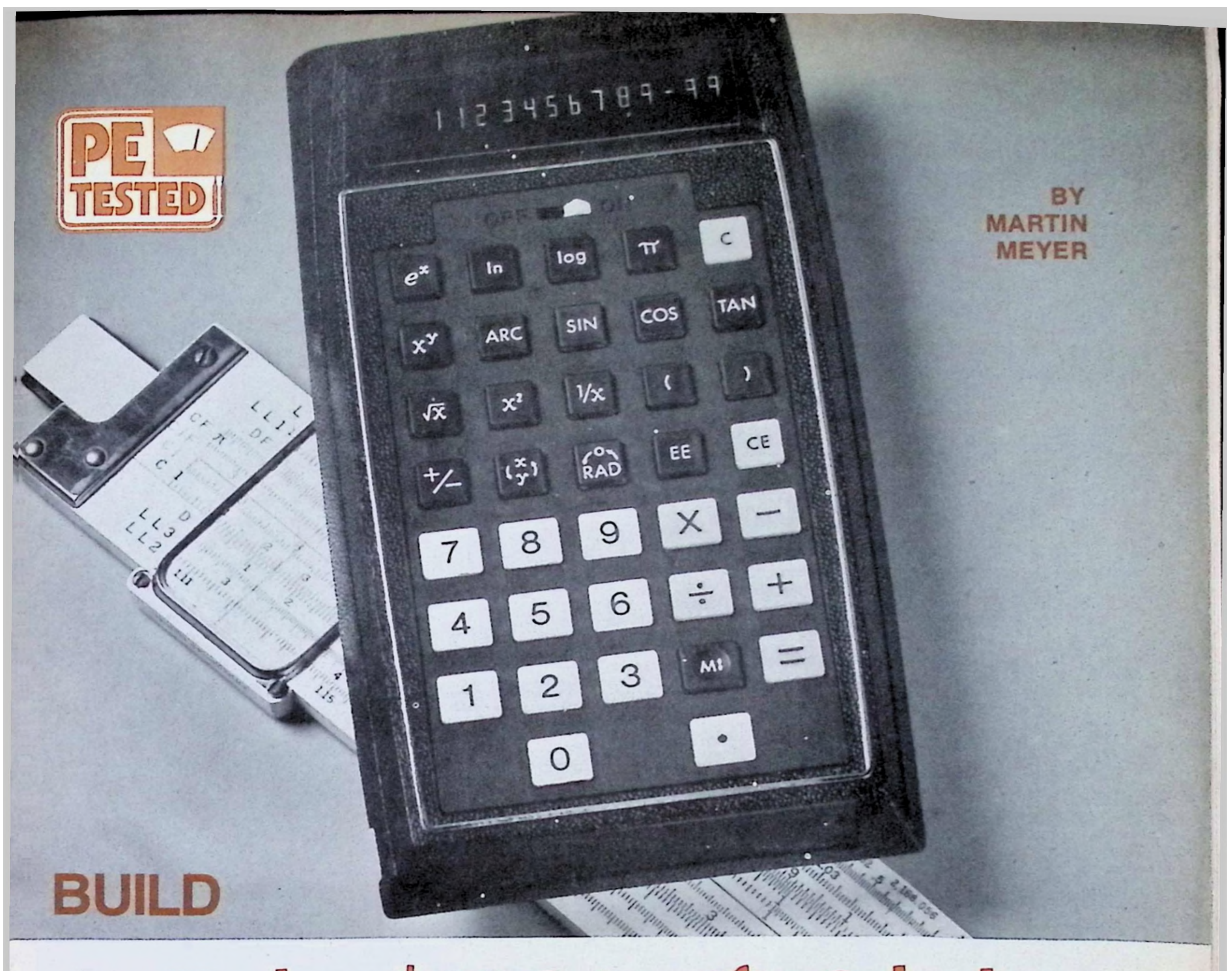


Fig. 4. Flashtube mounts in enlarged hole in light reflector.



PE TESTED

BY
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BUILD

An Under-$90 Scientific Calculator

Ten digits of mantissa with 2-digit exponent and a full range of scientific operations, including double-nested parentheses.

THE inexpensive four-function calculator is an eminently practical tool for everyday home and primary-school use; however, high-school students, engineering and science majors in college, and practicing engineers and scientists require more sophisticated equipment. Fortunately, there is a new breed of calculators that is rapidly gaining popularity in professional and advanced-student circles. Going by such names as "scientific" and "slide-rule" calculators, they expand by several magnitudes the number of functions and the information-handling capacities of "ordinary" calculators for limited uses.

Scientific calculators may be capable of obtaining *n*th roots and *n*th powers; trigonometric functions (sine, cosine, tangent, etc.); natural and common logarithms; degrees-to-radians conversions; and many other functions. As a general rule, these calculators also feature at least one level of store/retrieve memory, a 10-digit mantissa with two-digit exponent, and separate displays to indicate negative quantities (in both mantissa and exponent) and overflow and disallowed functions.

Most scientific calculators with the capabilities described above sell for $150 or more at this writing. But the Popular Electronics full-function, 200-decade scientific calculator costs only $89.95 in kit form. It is 3⅜" wide, 6" long, and 1½" thick.

What It Does. What can you, as an electronics experimenter, do with such a calculator? The answer is, just about anything you want to do in problem solving. For example, suppose you wanted to know the equivalent resistance of a network of three resistors (560 ohms, 390 ohms, and 670 ohms) in parallel. By hand, this problem might take you 10 minutes or more. With the calculator, less than 30 seconds is needed to get the answer (171.1638788.).

Approaching a more difficult prob-

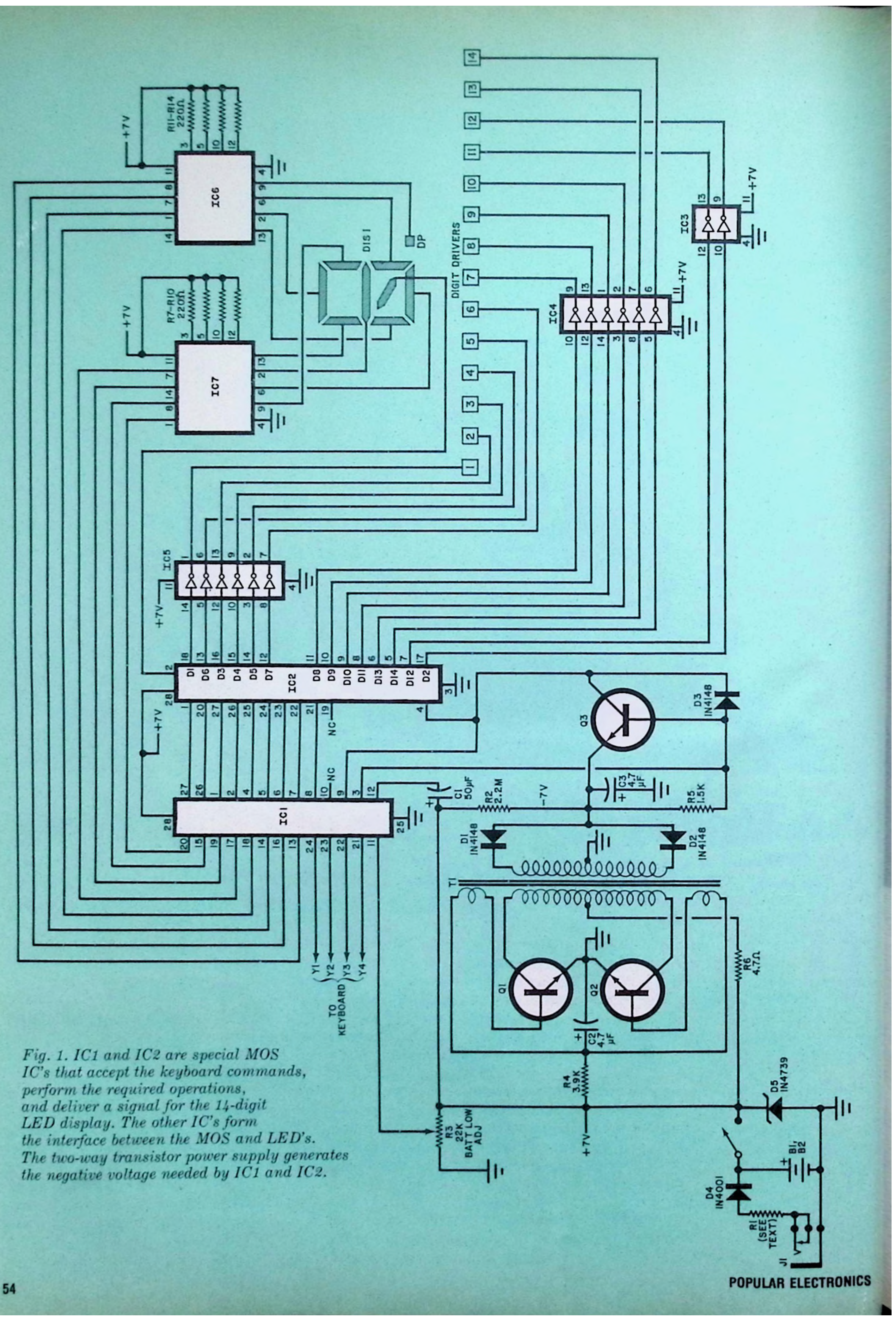
IC1
IC2
IC3
IC4
IC5
IC6
IC7
DIS1
DP
DIGIT DRIVERS
R11-R14 220Ω
R7-R10 220Ω
+7V
-7V
Q1
Q2
Q3
D1 1N4148
D2 1N4148
D3 1N4148
D4 1N4001
D5 1N4739
C1 50pF
C2 4.7 µF
C3 4.7 µF
R2 2.2M
R3 22K BATT LOW ADJ
R4 3.9K
R5 1.5K
R6 4.7Ω
R1 (SEE TEXT)
J1
B1, B2
T1
NC
Y1
Y2
Y3
Y4
TO KEYBOARD

Fig. 1. IC1 and IC2 are special MOS IC's that accept the keyboard commands, perform the required operations, and deliver a signal for the 14-digit LED display. The other IC's form the interface between the MOS and LED's. The two-way transistor power supply generates the negative voltage needed by IC1 and IC2.

PARTS LIST

B1,B2—3.5-volt rechargeable batteries
C1—50-√F, 6-volt electrolytic capacitor
C2,C3—4.7-√F, 10-volt electrolytic capacitor
D1 to D3—1N4148 diode
D4—1N4001 rectifier diode
D5—1N4739 zener diode
DIS1—14-digit light-emitting diode scientific display
IC1,IC2—MOS scientific calculator integrated circuits (see note)
IC3 to IC5—SN75492 hex inverter integrated circuit (Texas Instruments)
IC6,IC7—SN75491 7-segment driver integrated circuit (Texas Instruments)
J1—Subminiature phone jack
Q1 to Q3—2N5232 transistor
R1—Optional charging resistor (value contingent on charging current desired)
R2—2.2-megohm, ¼-watt resistor
R3—22,000-ohm miniature printed circuit potentiometer
R4—3900-ohm, ¼-watt resistor
R5—1500-ohm, ¼-watt resistor
R6—4.7-ohm, ¼-watt resistor
R7 to R14—220-ohm, ¼-watt resistor
T1—Special converter transformer
Misc.—Calculator case; keyboard assembly; recharger; mounting nuts (2); thin insulating washer; Molex Soldercon® printed circuit connectors; fine solder; etc.
Note: The following are available from Network Research Corp., 27 Eagle St., Spring Valley, NY 10977: complete kit of parts including manual, batteries, and ac adapter/recharger for $89.95 (New York residents add sales tax); #N1003 keyboard assembly for $12.00; #N1002 display assembly for $19.50; #N1001 etched and drilled pc board for $5.50; #N1000 MOS scientific calculator IC's for $60 the set; #N1005 transformer for $3; #N1004 interface IC's (5) for $9.50 the set.

lem, suppose you wanted to know the equivalent impedance of a 560-ohm resistor and a 25.5-mH choke at 2500 Hz. The solution, 687.5569736, takes about a minute with the calculator, considerably more time with paper and pencil.

To give you a better idea of how practical the calculator is, you can throw away your logarithm and trigonometry tables. You won't need them again because they are only a few keystrokes away in your calculator—all figured out to an accuracy of nine decimal places. And that goes for π as well. (A more detailed list of the capabilities of this calculator is given in the box.)

The POPULAR ELECTRONICS calculator has built into it two levels of nested parentheses, each of which defines a variable before executing a function command. This permits the problem to be "written" into the calculator exactly as it is written down on paper. When a new parenthetical statement is opened, the previous results and functions are stored in the calculator until that level of parentheses is closed later in the problem. So, a complex problem like

$$x = \sin\left[\frac{1}{1+\sqrt{(a+b)^2-(c+d)^2}}\right]^3$$

where $a = 4$, $b = 5$, $c = 2$, and $d = 3$ can be solved quickly with the aid of the parentheses. The keystroke sequence would be: 1, +, (, (, 4, +, 5,), x^2, −, (, 2, +, 3,), x^2,), $\sqrt{x}$, =, 1/x, sin, x^y, 3, =. When the last keystroke is executed, the display will read the answer, 8.70831579 −09, which means that the mantissa is the number shown raised to the negative ninth power of 10 (10^{-9}), which means further that the calculator employed another built-in feature—automatic scientific notation. (The calculator goes automatically to scientific notation whenever the solution is an excessively large or an excessively small number.)

Note that in the above sample problem no memory or external scratchpad was required to find the solution.

About the Circuit. The schematic diagram of the complete scientific calculator is shown in Fig. 1. Special MOS integrated circuits *IC1* and *IC2* are the heart of the circuit. They accept keyboard entries, perform all mathematical operations demanded, and deliver a multiplexed output to the driver circuitry for the 14-digit LED display. (The display consists of 10 mantissa digits, two exponent digits, one negative-sign digit for the exponent, and a final digit that combines the disallowed-function, minus-sign, and radian-function notation to the left of the mantissa.)

Buffers *IC3* through *IC5* drive the 14 digit-enable lines, while *IC6* and *IC7* are the segment drivers for the display. Note that all similar segments are driven simultaneously, with the digit selector choosing the correct digit of the moment.

Because the MOS chips require both positive and negative 7 volts dc referenced to common to operate and only a 7-volt battery is used in the calculator, a two-transistor (*Q1*/*Q2*) dc-to-dc voltage converter is required. In conjunction with *T1*, R4, and *C2*, the Q1/*Q2* circuit forms a push-pull power oscillator. The output of *T1* is rectified by *D1* and *D2*. It is then filtered by *C3* to deliver the −7 volts required. Transistor *Q3* is the power-saver switching regulator, while potentiometer *R3* permits adjustment of the battery's low-voltage cutoff point.

Rectifier diode *D4* converts the ac from the plug-in charger to pulsating dc for charging the two batteries. Zener diode *D5* keeps the voltage from exceeding the approximately 8 volts required for recharging. An optional resistor (*R1*) is used to limit the charging current to a safe level.

Construction. There is no practical way of assembling the calculator without the aid of a printed circuit board. Unfortunately, since the board must have conductors on both sides

FEATURES OF THE POPULAR ELECTRONICS FULL-FUNCTION SCIENTIFIC CALCULATOR

Basic arithmetic: add, subtract, multiply, divide
Any positive or negative number between 1.99×10^{-99} and 1.99×10^{99} can be entered and displayed
Entry can be in either floating point or scientific notation, with automatic conversion to scientific notation in very large and very small numerical results
Algebraic problem entry with two levels of parentheses
10-digit mantissa with 2-digit exponent numeric display, plus battery-low, minus-sign, radians, disallowed-function, battery saver display.
Positive/negative sign selection for mantissa and exponent
Transcendental functions: sin, cos, tan, $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$, common log, natural log, e^x, x^y
Convenience functions: $\sqrt{x}$, 1/x, x^2
Separate memory register for storage of constants or intermediate results
Chain calculations with any sequence of functions desired
Independent system and entry clear
Trigonometric functions can be performed in either degrees or radians
Separate ← key with 9 decimal place accuracy
Automatic display cutoff to conserve battery power
Rechargeable batteries
Battery charger that doubles as ac-operated battery eliminator

and the components must be mounted as close to the board's surface as possible, there is no practical way of making this board at home. While you might be able to make the required double-sided board at home with all points properly registered, there is no known method that can be used at home to plate-through the holes. Hence, you will have to purchase the pc board from the supplier listed in the Parts List.

Shown in Fig. 2 is the component-placement guide for the main board assembly. The view is from the component side of the board. (The two sides of the board are readily identifiable because the bottom side on which no components are mounted bears the legend BOTTOM.)

Start assembly by installing and soldering into place the fixed resistors. Then proceed to installing the three electrolytic capacitors, the diodes, and the transistors, taking care to observe proper polarity and basing. Mount the transistors close to the board's surface. Use a fine-pointed soldering tip, thin-strand solder, and a minimum of heat. Frequently clean the soldering tip with a damp rag to remove excessive buildup of solder. This will minimize the possibility of solder bridges between the closely spaced foil conductors. *Do not touch or remove the MOS IC's (IC1* and *IC2) from their carriers until instructed to do so.*

If you inspect *T1*, you will note that there are three pins in one of its corners. These pins serve as the installation "key." Install and solder into place the transformer. Potentiometer *R3* mounts in the upper-right corner of the board. Then install *IC3* through *IC7* in their respective locations, carefully observing the notch code. As you proceed, carefully inspect the board for the presence of solder bridges. If you locate a solder bridge, reflow the solder and remove the excess.

Install the two flat (negative) battery contacts as shown. Solder them at both ends and on both sides to the copper conductors. (Note: There are small holes in the board and the battery contacts are dimpled. When properly installed, the contacts are positioned with their dimples engaging the holes.) Install and solder into place the spring-type battery contacts, making sure that the pin-connector side is vertical to the plane of the board. Mount and solder into place jack *J1*.

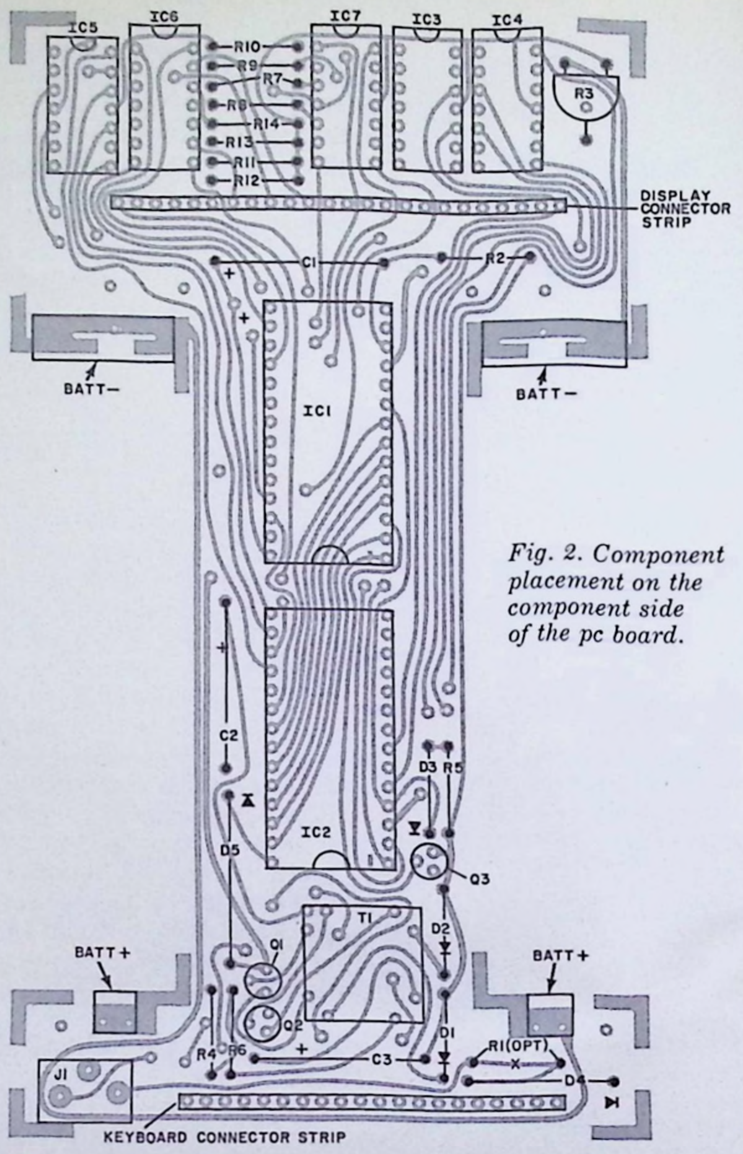

Fig. 2. Component placement on the component side of the pc board.

Straighten a strip of 24 Molex Soldercon® connectors but do not remove the connector strip. Force the end pins of the strip through a 2½-in. by ⅛-in. (16- × 3.2-mm) piece of masking tape from the non-adhesive side. Mount the connector strip in the holes just below the five IC's at the top of the board, pressing down to seat the tape firmly against the board's surface. Flip over the board and solder the protruding pins to the copper foil. Be very careful to avoid solder bridges. Flip over the board again and, using long-nose pliers, bend the connector strip back and forth until it parts from the connectors. Be careful to align the connectors properly.

In the same fashion as described above, mount a strip of 20 Soldercon connectors along the lower edge of the board. This time, use a 2-in. (51-mm) length of masking tape. (The upper strip of connectors is for the display interconnect, while the lower is for the keyboard interconnect.)

Straighten four Soldercon strips, each consisting of 14 connectors. Install these in the holes for *IC1* and *IC2*. Then, before breaking away the connector strips, make sure the connectors are straight and that the IC pairs are parallel to each other. Now, before you even consider opening the carrier in which *IC1* and *IC2* are packed, carefully read and become familiar with the procedures for handling MOS devices by reading the instructions given in the box on page 57.

With yourself properly grounded and all conditions for good MOS-device handling met, open the carrier.

With the IC's still in the carrier, determine which is which and the locations of pins 1. Pin 1 is near the small bump on each IC. To be absolutely certain of pin 1 on each IC you can use a small magnifying glass to check the IC leads near where they enter the packages. Only pin 1 in each case has a tiny hole drilled through it.

With the forefinger of the hand you have grounded pressed against the metal plate on top of *IC1* remove the IC from its carrier. Check to make sure its leads are in straight lines. Then carefully install the IC in its appropriate connectors on the board. First engage the pins along one side of the IC in the connectors. Once this is accomplished, work the leads along the other side into their connectors. Apply firm, even pressure to the IC to seat it in its connectors. Do not force the IC into the connectors or subject it to torsional forces or you might misalign or even break off pins. If insertion is difficult, replace the IC in its carrier. Then, insert and remove an old IC in the connectors several times to "form" them. Any DIP IC will do; just make sure to cover all connectors. Now, install the IC from the carrier.

Repeat the above procedure for *IC2*.

The display comes as a completely wired assembly, with its 24 connector pins already mounted in place. Just make sure that the pins are in a straight line. Carefully fit the display-board pins into their respective connectors on the main board. Press the display board into place so that it rests on the five upper IC's with a slight tilt.

The keyboard also comes as a complete assembly, including connector pins. Straighten any out-of-line pins and engage them in the connectors along the lower edge of the main board. Gently seat the keyboard assembly in place until the narrower portions of the upper two plastic posts on the keyboard assembly engage the smaller of the holes above the negative-terminal battery contacts on the main board.

Slide the entire assembly into the top half of the calculator case until the two small plastic tabs on the bottom end of the keyboard engage the molded slots in the case top. At this time, two threaded plastic posts should appear through the holes immediately above the negative battery contacts on the main board, and *J1* should slightly protrude through its slot in the case.

Holding the board assembly in place in the case, secure the two together with small nuts over the threaded posts. (Note: Because of possible interference between nut and close-by foil conductor near the left post, precede the nut here with a thin insulating washer.)

Place the power switch in the OFF position, and tape it in place until the batteries have been installed. The batteries are marked with + and − signs. The + sides are protected by sleevings that extend beyond the bodies of the batteries. The sleevings are notched in such a manner that the batteries will fit into their respective locations in only one way. Slip the batteries into place. This completes construction.

SAFE HANDLING OF MOS IC'S

Prior to any construction and before removing MOS IC's from their protective carriers, it's imperative that certain precautions be understood and followed:

All insulated-gate MOS devices can be permanently damaged by excessively high electronic fields. Random electrostatic charges *must* be kept away from MOS devices. Anyone who handles the devices should wear anti-static clothing (preferably cotton) and, if possible, cotton gloves. Do *not* wear synthetic fabrics, particularly nylon; they readily build up static charges.

All working surfaces where MOS devices are handled should be conductive and at ground potential. Before handling, you should also be grounded. And avoid dropping MOS devices because of possible contact with charged surfaces or objects.

All apparatus that is to come into contact with MOS devices must be grounded, including your soldering iron's tip. Never insert or remove a MOS device in a powered circuit. When inserting or removing a MOS device, touch the grounded surface only after you have grounded yourself. If possible, ground the conductor pattern around the area where the device is to be installed with conductive tape or aluminum foil during installation and removal. When a good MOS device is removed from a circuit, immediately install it in a protective carrier.

You can ground the tip of your soldering iron by wrapping around its thick portion a copper strap and fastening the strap to a length of meshed cable. The free end of the cable then goes to a good ground. To ground yourself, use a similar procedure. Wrap a length of meshed cable snugly around your working-hand wrist and connect the free end of the cable to a good ground.

Checkout and Adjustment. Plug the recharger into *J1* and let the batteries charge for a few hours. Then disconnect the charger. Remove the tape from the power switch and set it to ON. The right-hand mantissa digit and its decimal point should come on, displaying 0. Leave the power applied and, after about a 30-second delay, the 0 and decimal point will blank out, being replaced by a minus sign in the exponent display. This indicates that the battery-saver feature is working.

Press the clear (C) key to restore 0. to the display. Feed in the numbers 1 through 0; operate the +/− and EE (enter exponent) keys; feed in 88; and press the +/− key. The display should now read −1234567890−88. Press the degrees-to-radians key; a small diagonal bar segment should come on to the extreme left of the display. Operate this key again, and the bar should extinguish. Press the C key.

Press the π key. The display should now read 3.141592654. Depress C. Now, with 0. displayed in each case, press log (common logarithm), 1n (natural logarithm), and 1/x (reciprocal). In each case, before depressing C, the disallowed function indicator, an inverted L, should show at the far left of the display.

To adjust battery-low indicator potentiometer *R3*, it is necessary to first fully charge the batteries. Plug the battery charger into *J1* and the ac outlet. With the power switch set to OFF, charge the batteries for about 8 hours. Then use the calculator for about 4 hours. Then, with the power ON, adjust *R3* with a thin-bladed screwdriver through the hole in the bottom of the main board, until the battery-low indicator (an L at the left of the display) comes on.

Install the back of the calculator case by inserting the two bottom "hooks" into their respective slots at the bottom end of the calculator. The top end simply snaps into place. A narrow slot at the top of the case is provided to permit the case to be reopened as desired with a coin or screwdriver blade. Simply twist.

The calculator can be operated from fully charged batteries for about 4 to 5 hours. When the charge runs down, simply plug in the recharger. Recharging takes 8 to 10 hours. The battery charger can also be used as a convenient battery eliminator. However, *under no circumstances should the recharger be used if there are no batteries in the calculator.*

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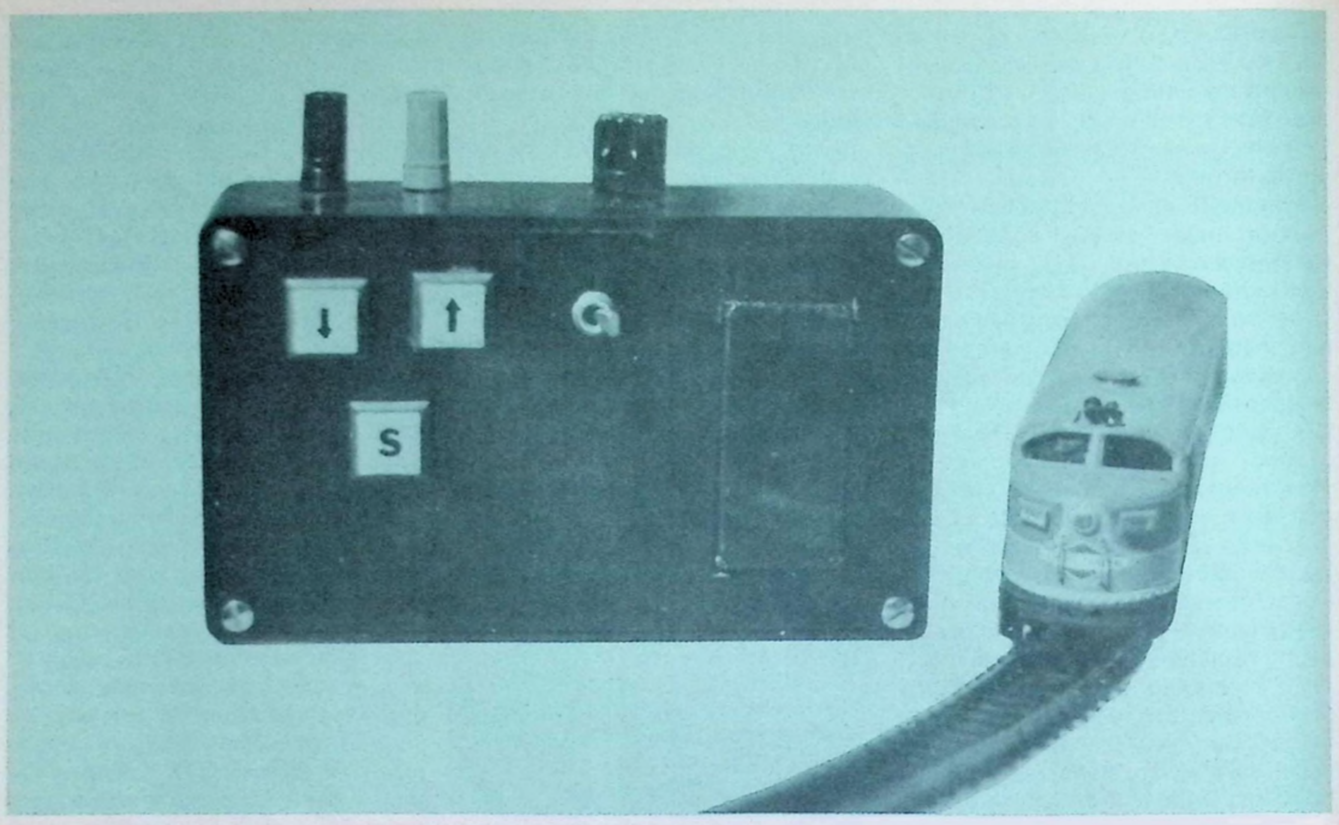


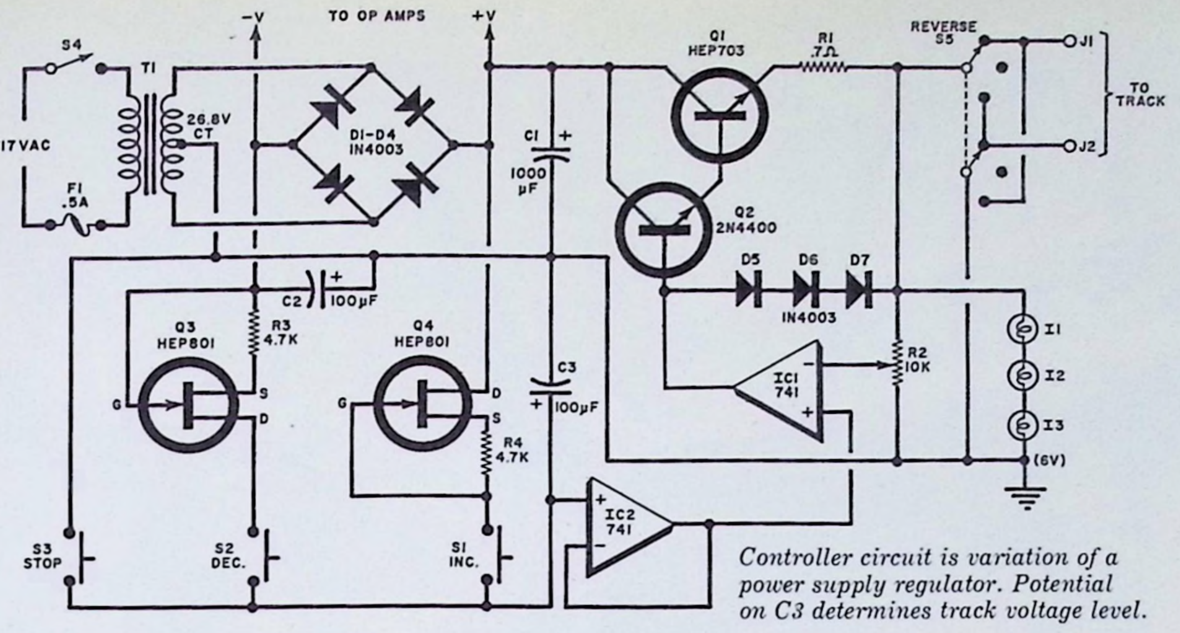
IC Speed Controller for HO Model Railroads

Precision low-cost device provides full control flexibility and simple speed indication option

BY ROBERT D. PASCOE

WITH A PAIR of integrated-circuit operational amplifiers and a handful of parts, you can build a precision speed controller for HO-gauge model railroads at minimal cost. The solid-state controller features forward/reverse, stop, increase-speed, and decrease-speed switches for full control flexibility. In addition, optional lighted pushbutton switches can be used to provide a visual indication of how fast the train is moving on its tracks. The faster the train moves, the brighter the light from the lamps.

About the Circuit. Operational amplifier *IC1*, in conjunction with transistors *Q1* and *Q2* (see schematic diagram), forms a voltage regulator circuit. The output voltage from this circuit is determined by the voltage at the wiper at potentiometer *R2* and the dc voltage across capacitor *C3*. Op amp *IC2* is connected in a voltage-follower configuration. The dc voltage across *C3*, the reference for the regulator, is a product of the time a constant current is "pumped" into the capacitor. The two current "pumps" in this system are made up of the *Q3* and *Q4* circuits, with *Q3* the negative and *Q4* the positive pump.



Controller circuit is variation of a power supply regulator. Potential on C3 determines track voltage level.

PARTS LIST

C1—1000-µF, 50-volt electrolytic capacitor
C2, C3—100-µF, 50-volt electrolytic capacitor
D1-D8—1N4003 (or similar) silicon diode
F1—0.5-ampere fuse
I1-I3—6-volt pilot lamp (optionally in S1-S3)
IC1, IC2—741 operational-amplifier integrated circuit (or use dual version)
J1, J2—Banana jack (one black, one red)
Q1—HEP-703 power transistor (Motorola)
Q2—2N4400 transistor (or use Motorola HEP-736)
Q3, Q4—HEP-801 FET (Motorola)
R1—0.7-ohm resistor (four 3.3-ohm, ½-watt resistors in parallel)
R2—10,000-ohm potentiometer
R3, R4—4700-ohm, ½-watt resistor
S1-S3—Normally-open pushbutton switch (Use Switchcraft No. LUS-05-01 if built-in 6-volt lamp is desired)
S4—Spst slide or toggle switch
S5—Dpdt, center-off switch
T1—26.8-volt, 1-ampere transformer
Misc.—Heat sink for Q1; suitable enclosure; fuse holder; socket(s) for *IC1* and *IC2*; perforated board and solder clips; line cord; strain relief or rubber grommet (for line cord exit hole); dry-transfer lettering kit; machine hardware; hookup wire; solder; etc.

Depressing increase speed switch *S1* causes the output voltage at the tracks to increase. Conversely, depressing *S2* causes the output voltage to decrease. And pressing stop switch *S3* causes the output voltage to immediately drop to zero.

A visual indication of the speed at which the train is moving is obtained by observing how bright the light is from lamps *I1-I3*. One of these lamps is (optionally) inside each pushbutton switch. The greater the track voltage, the faster the train is moving on the tracks, and the brighter the lamps.

The three-diode current limiter composed of *D5-D7* holds the current being fed to the tracks to approximately 1 ampere. Hence, the circuit is protected in the event the train tracks should accidentally be shorted to each other.

Construction. Owing to the simplicity of the circuit, the entire controller, except for *T1* and the switches, can be mounted on a piece of perforated board with the aid of push-in solder terminals and sockets for *IC1* and *IC2*. Series-pass transistor *Q1* must be mounted in an aluminum heat sink with about 9 sq in. (58 sq cm) of radiating area.

You can mount the circuit board assembly and transformer in any suitable enclosure. The control switches and potentiometer are best mounted on the top of the enclosure, while output jacks *J1* and *J2* are more conveniently located on the rear of the enclosure, as is the exit hole (strain relieved or rubber-grommet-lined) for the line cord.

In Use. The upper voltage limit to the tracks is determined by the setting of potentiometer *R2*. To adjust *R2*, depress increase-speed switch *S1* for 10 seconds. The glow of the three lamps will increase in brilliance during this interval. Set *R2* for the desired upper-limit track voltage.

The speed at which the track voltage increases and decreases is determined by the two current pumps (*Q3* and *Q4*). With the components specified in the Parts List, the voltage change rate is about 2 volts/second. Increasing the values of *R3* and *R4* decreases the rate of change, and vice-versa.

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BY DON LANCASTER

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KEYING & VCA CIRCUITS FOR ELECTRONIC MUSIC INSTRUMENTS

PART I

The keyer combines pitch and envelope information in an amplifier to shape a realistic mode.

KEYING circuits go by many names. In organs, they are called simply keyers; in traditional electronic synthesizers, they are often called voltage-controlled amplifiers (vca's), envelope shapers, or modulators. Functionally, they are electronic multipliers. All of them do the same job—they combine pitch information with the envelope information to produce a realistic note or note sequence.

Done properly, this sets the attack, sustain, fallback, decay, and snubbing of any note on an individual basis. Envelope control can also introduce such special effects as percussion, the "bite" on the leading edge of a horn sound, echos, tremelo, and noise modulation.

A very few older organs did not employ keyers. They simply applied and removed the supply voltage to and from oscillators or used the keys themselves as off/on note controllers. Envelope shaping ability is very limited by this means. At the other extreme, some true computer composing circuits and programs completely specify the amplitude and frequency instantaneously. With these exceptions, virtually every other electronic music system generates tones and envelope information separately. These two signals are then routed into a circuit that provides a combination of the desired loudness and frequency.

The keyer or vca might work on any note in a monophonic instrument, or one individual keyer can be supplied with each note in a polyphonic system. We can use much more sophisticated keying circuitry if we need only a few, rather than one for each note. Keying or envelope shaping can take place either before or after the tinbre or tone-quality circuitry, working either with the raw frequencies as generated or the final highly structured harmonic tone. Organs usually employ fixed formant filters; and a polyphonic instrument is usually keyed first and voiced later. In synthesizers, the note will more often be colored by a patchwork of voltage-controlled oscillators (vco's) and filters (vcf's), and then envelope shaping takes place.

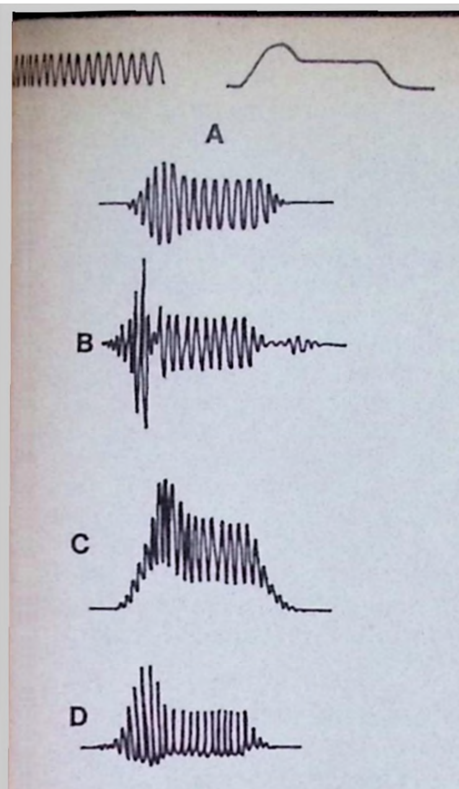

Fig. 1. In a good keyer, pitch and envelope waveforms (above A) are combined to produce a note which is their mathematical product (below A). Output of poor keyer (B) has excessive transients; (C) has envelope in output; (D) has unequal positive and negative swings.

What a Keyer Does. Any keying circuit must simply control the gain of the tones fed through it. In Fig. 1 are shown some good and some bad things keyers do. The keyer must behave as a linear, electrically bilateral variable resistor. Ideally, it must introduce no coloration or significant distortion of its own (Fig. 1A).

A keyer must be transient-free. This means that no ringing or overshoot can be permitted as in Fig. 1B. It also means that no feedthrough of the envelope information to the output can be permitted (Fig. 1C). The result of feedthrough is a loud thump and other response-recovery problems later on in the circuit. Any keyer circuit in which the dc output level changes as a function of the envelope command is bound to be a bad design and will thump badly.

A keyer must treat positive and negative signal swings equally, amplifying or attenuating them with equal gain (Fig. 1D). And the keyer system must have a wide enough frequency response to follow faithfully the envelope and pass all frequencies of the tone or waveshape without behaving like a low-pass filter.

To be useful in a circuit, the keyer should have a medium-to-high tone input impedance and a low output impedance so that it can drive output and timbre circuitry without difficulty and does not load down the tone source too heavily. The impedance at the envelope input would ideally be infinite so that large-value resistors and economical small capacitors could be used for attack-sustain-decay shaping. This is particularly important on polyphonic instruments where a hundred or more keyer circuits might be needed.

Keyer design is no simple task, since it shares all the woes of any faithful electronic analog or digital multiplication problem. Let us look at some popular approaches to keyer design. In this first part of our two-part article on keyers, we will discuss diode, differential-amplifier, four-quadrant multiplier, and gain block keyers. Next month, JFET, MOSFET, Transconductance-amplifier and CMOS keyers.

Diode Keyer. The diode keyer is by now, fairly obsolete. An ordinary silicon diode has its small-signal (50 mV or less) ac impedance set by the direct current through the diode. If there is no current, the diode is an open circuit. For small direct currents, the impedance presented to ac signals is given by the ratio 26/I, where I is the current in milliamperes. So, a diode carrying a 0.5-mA current "looks" like 52 ohms to a low-level ac signal routed through it.

In Fig. 2A, one capacitor is used to couple a tone into the diode and use the envelope information to set the direct current through the diode. The disadvantage of this circuit is that it will thump as the envelope appears in the output. A second diode and equal positive and negative signal swings (Fig. 2B) from the envelope circuitry overcome this disadvantage. The two diodes are in series across the envelope circuit but in parallel with the tone input. Two more diodes (Fig. 2C) eliminate the extra coupling capacitor.

Input impedance is low, output impedance is high, and a wide voltage swing into a medium resistive load is needed for the envelope input. But if the diodes are identical and if the control voltages are also identical, and if the ac signal level is low enough, the diode keyer can operate without introducing intolerable distortion, and it

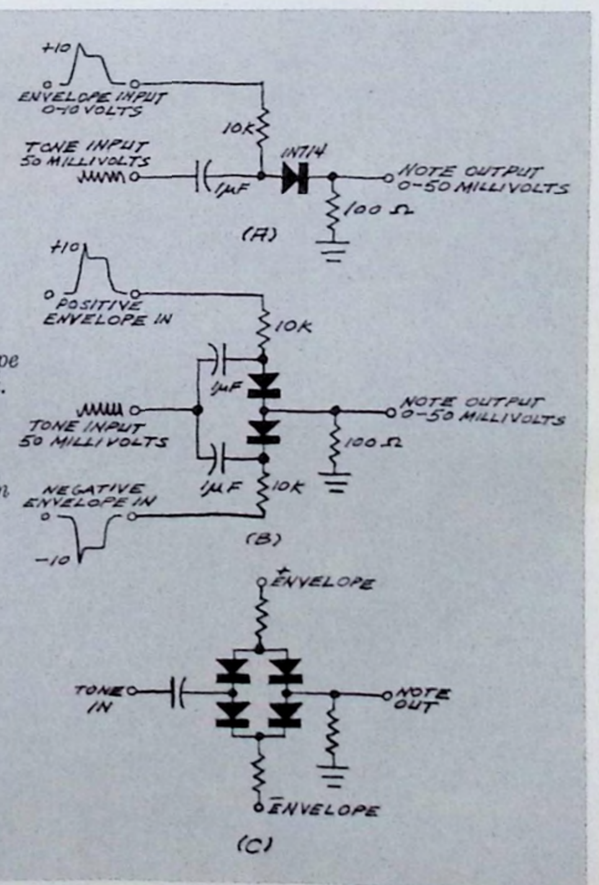

Fig. 2. Simple diode keyer (A) thumps as envelope appears in output. Two diodes (B) eliminate most of output thumping. Four-diode version (C) saves one capacitor and has lower distortion.

will not cost much to make. (A diode keyer will always add some distortion.)

Various transistor schemes have been used in keying setups. They are basically diode keyers that use the base-emitter junctions of transistors as the multiplier elements. They ease the loading and impedance problems, but they can introduce thumping if they are not properly designed. Today, we have much better methods.

Differential Amplifier. In Fig. 3A is shown a differential amplifier. It is the most commonly used amplifying circuit at this time and is found in almost all linear integrated circuits. A differential amplifier normally amplifies the difference between two input signals. In Fig. 3A, one input is tied to ground to provide single-ended-input operation. This circuit can be used as a keyer by routing the tone signal into input X and the envelope into input Y.

If a fixed voltage is applied to input Y, some emitter current will appear in *Q1* and *Q3*. Input A goes to *Q1* and comes out of the transistor's emitter. The emitter signal drives *Q3*, which is operated as a grounded-base stage, and an amplified version of the input signal appears at *Q3*'s collector.

The gain of the circuit in Fig. 3A is obtained from the formula IR/104 where R is the *Q3* collector load resistance in kilohms and I is the emitter current in *Q3*, the 104 comes about because *Q3* receives only half the available current and because *Q1*'s output impedance is equal to the input impedance of *Q3*, which yields a second 2:1 attenuation.

It is important to note that the gain is directly proportional to the emitter current. Change the voltage on input Y, and the gain changes, and the product of the envelope and tone input signals is obtained. This type of circuit is called a vca. It bilaterally and at high speed gives the product of the two input signals.

One obvious problem with this circuit is that the dc drop across *Q3*'s collector load resistor follows the envelope, resulting in two output terms—the desired shaped tone and an undesirable thumping from envelope feedthrough. In Fig. 3B, a second load resistor, in the collector circuit of *Q1*, has been added. This circuit has two outputs, one of which is in-phase and the other out-of-phase with the input. Both outputs bounce up and down together.

A good differential amplifier ignores the common-mode up-and-down bouncing of the input signals. It is only the difference between the two signals that matters. So, by simply adding still another differential amplifier stage to the one shown in Fig. 3B, the output stays at a fixed dc level regardless of the envelope and is a thump-free replica of the desired signal.

Differential amplifiers are widely used in synthesizer vca's. While many similar devices exist, the RCA CA3000 series linear IC's offer many differential-amplifier possibilities. An ordinary 741 or 5558 operational amplifier can be used to eliminate the common-mode thumping on the last stage. The differential-amplifier vca offers good input and output impedances, controllable gain, and large signal swing. The envelope signal must be referenced to a negative supply, and the input impedance might be a bit lower than we would like it to be. Dynamic range is good and distortion is low, but the system becomes a bit complex if a separate circuit is used for each polyphonic note. The differential-amplifier vca is a very good choice for monophonic synthesizer circuits.

Four-Quadrant Multiplier. A four-quadrant multiplier is a true electronic multiplier that provides the product of the envelope and pitch inputs directly. No offsets are needed on the envelope input, and the output is normally referenced to ground.

A typical four-quadrant multiplier circuit is shown schematically in Fig. 4. The multiple paths through all the differentially-arranged transistors provide for automatic cancelling of common-mode feedthrough and thumping. As a sometimes handy gimmick in some advanced synthesizers the phase of the tone signal is reversed by inverting the envelope.

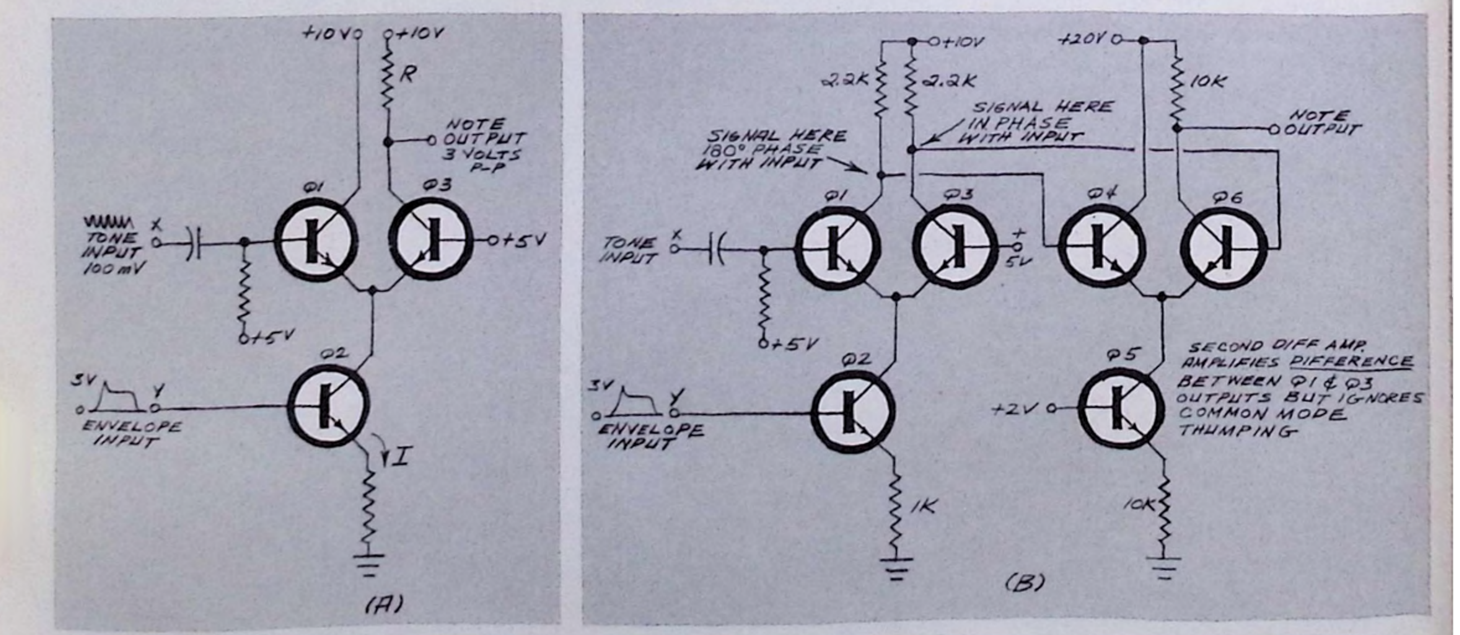

Fig. 3. In basic differential amplifier (A), envelope causes thump in the output. An additional amplifier can be added (B) to eliminate thump. Second stage can be an ordinary 741 operational amplifier.

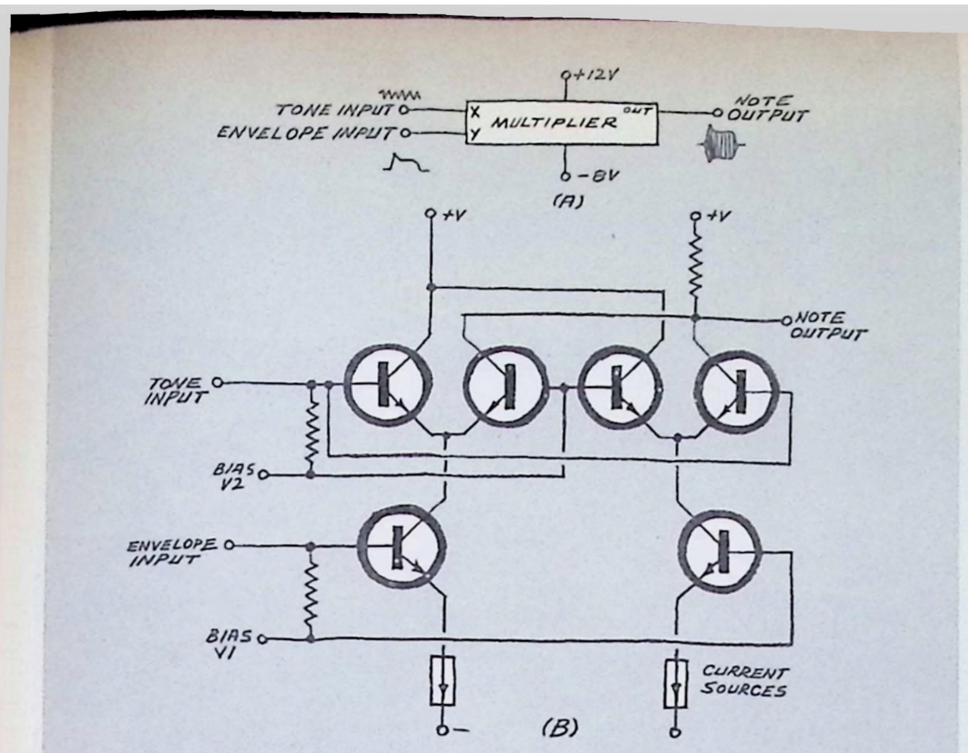

Fig. 4 (A) are typical connections for 4-quadrant multiplier. Key internal circuitry is shown at (B).

Typical four-quadrant multiplier IC's include Motorola's MC1595 and Analog Devices' AD532. Alternatively, you can use the much lower priced Signetics 5596 as the key component in a multiplier of your own design.

The only real disadvantage with the four-quadrant multiplier is its cost. None of these IC's is inexpensive. Some exceed $20 each and obviously are too costly if you are considering using one for each note in a polyphonic system. Aside from this, the four-quadrant multiplier is just about the best you could hope for.

Gain Block. Several linear IC's offer remote-controlled gain capability that can be used as a keyer circuit. Motorola's MFC6040 is a typical example of such a circuit (Fig. 5). It costs about $1. Its circuit is one more variant on the differential-amplifier theme with common-mode bucking. Typical voltage gain, wide open, is 3:1 or 10 dB; attenuation can go as low as 70 dB below full output.

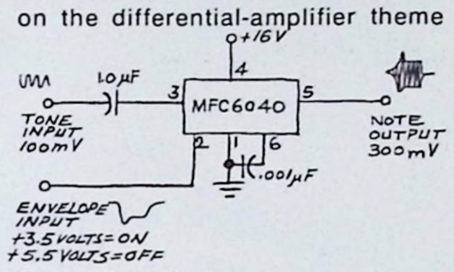

Fig. 5. Gain block envelope shaper.

The output swing of the MFC6040 can be up to 6 volts peak-to-peak. One potential disadvantage of the circuit is that the attenuation is somewhat nonlinear.

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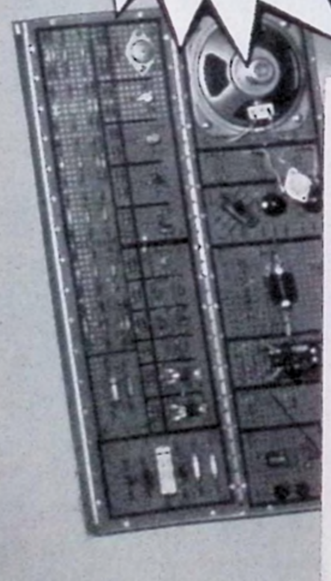

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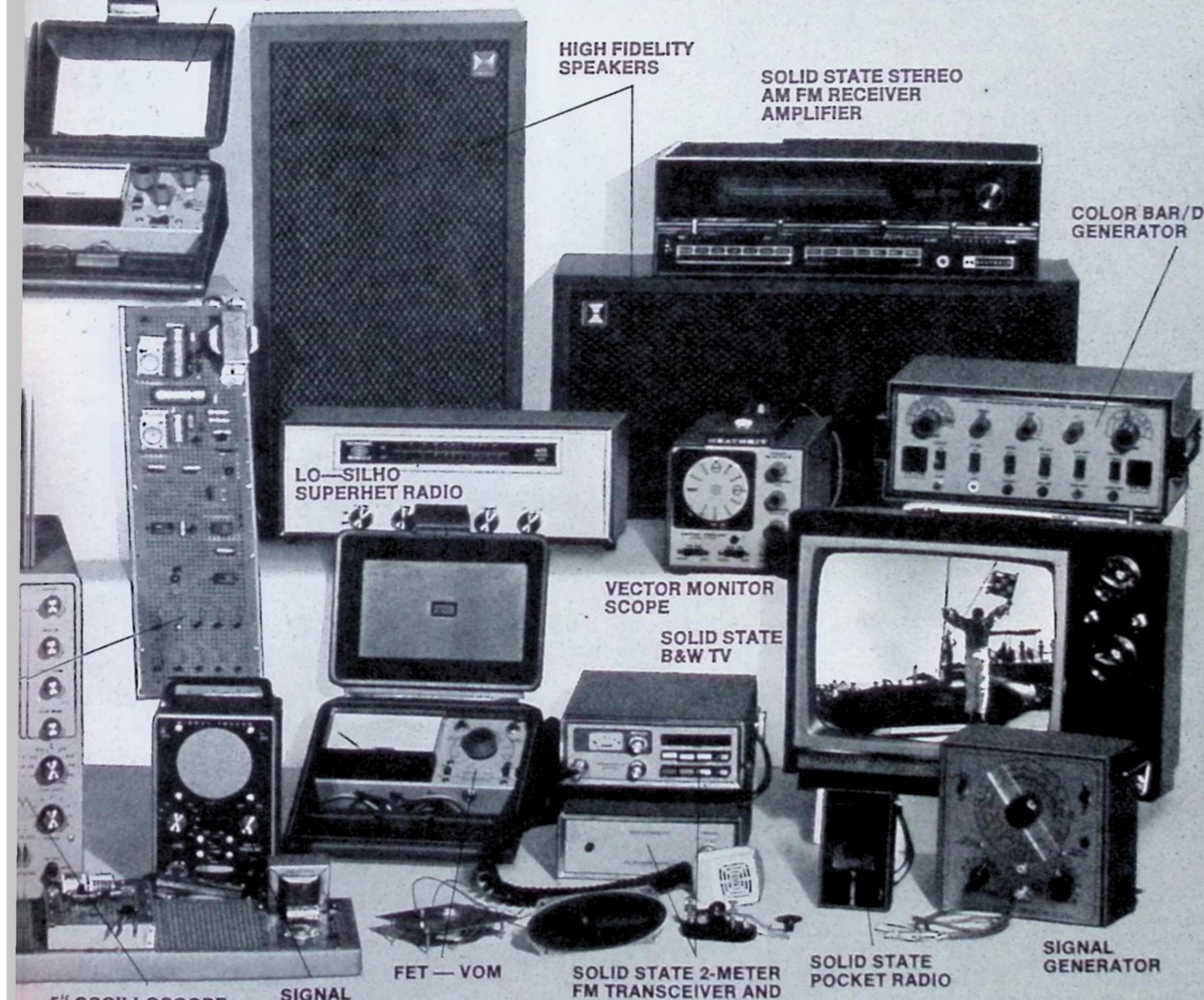
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HOW TO "READ" FM TUNER SPECS

BY JULIAN D. HIRSCH

THE tuner is the "radio" portion of your music system. Although most tuners cover both the AM and FM broadcast bands (and proposed government legislation will make this mandatory), the following comments apply specifically to FM tuners.

The tuner's function is to separate one desired signal from the many intercepted by the antenna, amplify it millions of times, convert its frequency modulation to an exact facsimile of the original program, and (if it is a stereo program) subject the detected signal to a complex process which separates it into left and right stereo channels.

Like amplifiers, most tuners tend to sound pretty much alike on ordinary program material. Many people place great store in numerical specifications for such characteristics as sensitivity and selectivity. Actually, neither of these is easy to reduce to a single convenient number that defines that aspect of the tuner's performance. Numbers *are* used, of course; but they are frequently misunderstood or misinterpreted.

Sensitivity. This refers to the ability of a tuner to receive a weak signal with acceptably low noise and distortion. The IHF Usable Sensitivity rating is most often quoted, although it does not correspond to a really listenable signal. Most good tuners have an IHF sensitivity of less than 3 μV, and some are as low as 1.5 μV. Although in practice it would not be possible to detect any real difference between two tuners whose sensitivities differed by a factor of two (all else being equal), there is a tendency to make much of differences of a few tenths of a microvolt, a quite insignificant amount. More meaningful is the 50-dB Quieting Sensitivity rating included in a proposed IHF tuner standard, but not yet in wide use. Our test reports in POPULAR ELECTRONICS do include it, however. This is usually in the range of 3 to 7 μV and represents the weakest mono signal that can be received without excessive background hiss. For stereo reception, all these sensitivity figures should be multiplied by a factor of ten, which may explain why stereo sensitivity ratings are not widely publicized!

Of course, these sensitivity numbers have no absolute meaning to the consumer who cannot know the actual received signal strengths in his area. In rural locations, one can indeed find signals of a few microvolts, and sometimes the highest possible tuner sensitivity is needed in such locations. In most urban and suburban locations, the tuner receives from its antenna hundreds or even thousands of microvolts from dozens of stations.

Selectivity. Clearly, high sensitivity is not likely to be an important tuner rating for the city dweller. What about selectivity? FM stations in any given area are assigned to channels at 400-kHz intervals (alternate channel spacing). If you are located close to a powerful FM station and wish to receive a far-off station only 400 kHz removed, you will need high alternate-channel selectivity. Most FM tuners have selectivity ratings between 45 and 60 dB, which is generally adequate for interference-free reception. If you have a "problem," there are some tuners whose alternate-channel selectivity is 90 dB or more. They are expensive, but well worth it if you need their special qualities.

In strong-signal areas, some tuners are subject to spurious responses—signals appearing on the dial in unexpected places and sometimes interfering with a desired signal. The relevant ratings—image rejection, spurious rejection, i-f rejection—are also expressed in decibels, with the higher numbers being better.

Capture Ratio. A major cause of distorted FM sound is multipath reception, caused by a signal reflecting from various structures and reaching the antenna from different directions and at slightly different times. The tuner specifications related to low multipath distortion are capture ratio (the lower the better, with most good tuners under 3 dB and the best reaching 1 dB or less), and AM rejection (ratings in excess of 50 dB are good, and a few are as high as 70 dB). You should be aware that no tuner can be completely immune to multipath distortion and that the best cure for this and most other FM reception problems is a good directional antenna which can be rotated to obtain best results.

The tuner distortion rating should be well under 1%, and most good tuners are rated between 0.2% and 0.5% in mono, and about twice as much in stereo. Stereo channel separation varies with modulating frequency, but is often specified at 400 Hz or 1000 Hz, where it is greatest. Comprehensive ratings include a definition of separation over a range of frequencies, such as 100 to 10,000 Hz. If the separation exceeds 20 dB over most of the audio range, you can be assured of a satisfactory stereo effect. Many tuners in all price ranges have 30 to 40 dB of separation over most of the audio band.

Operating Ease. Many important tuner differences relate to their ease of operation, rather than their electrical performance. The tuning dial should be legible and well calibrated. (Some tuners, even high-priced units, are difficult to set accurately to a known frequency because of inadequate dial calibration.) The tuning "feel" should be smooth and positive. Tuning indicators, whether meters or lights, should give an accurate indication of correct tuning. Interstation-noise muting circuits should be free from bursts of noise as one tunes through a station (although many are not). All of these characteristics are easy to judge for yourself and require no technical knowledge.

There are several tuners with digital frequency readouts instead of the usual slide-rule dial. This eliminates any problems of dial calibration but adds appreciably to the cost of the tuner. Compensating for their higher prices is the fact that most digital tuners also have above-average performance in most other respects relating to high fidelity. ◆

Identifies leads on unknown transistors, indicates PNP or NPN polarity, and shows up bad devices

BUILD THE
TRANSISTOR IDENTOMETER

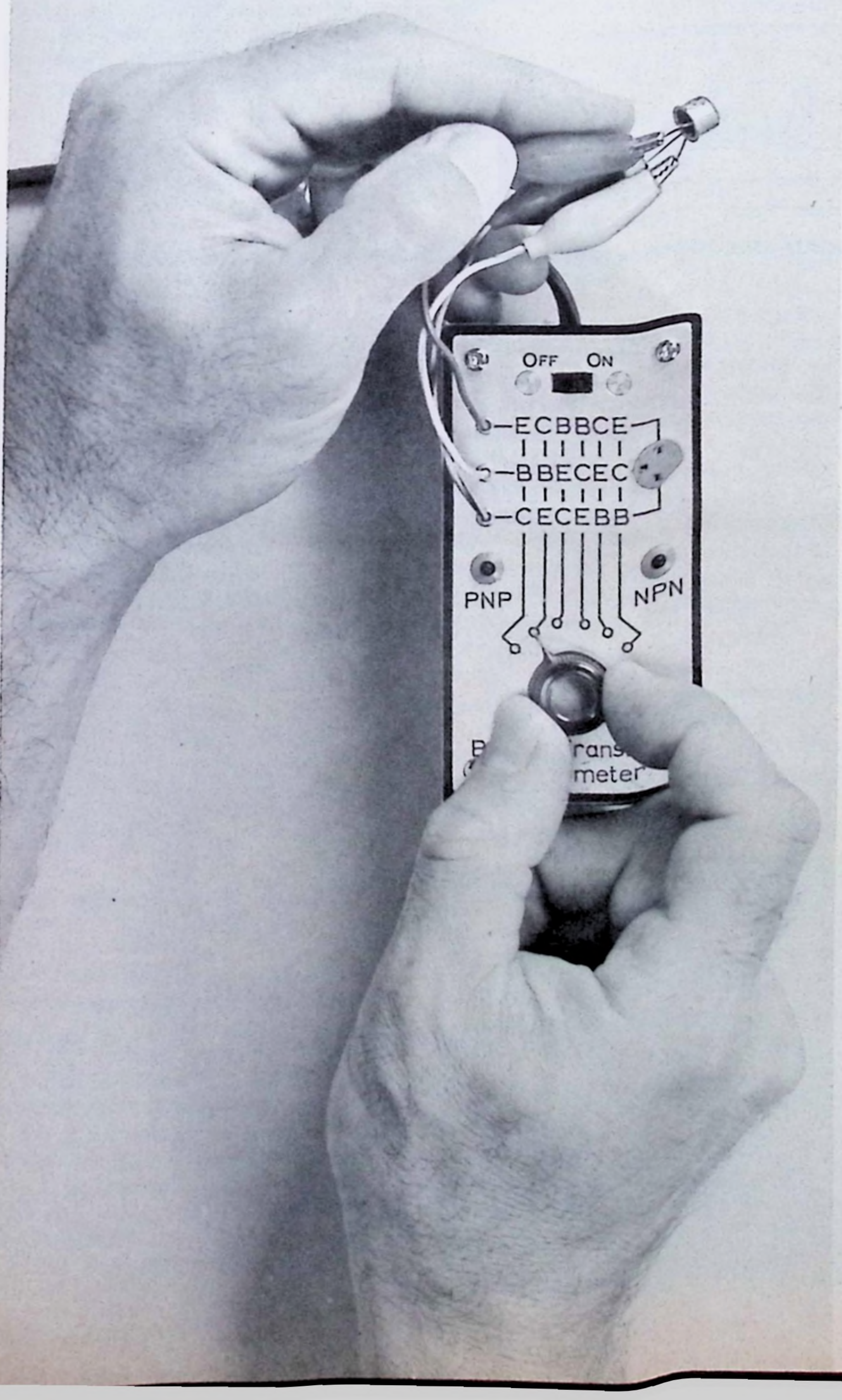
BY JOHN T. BAILEY

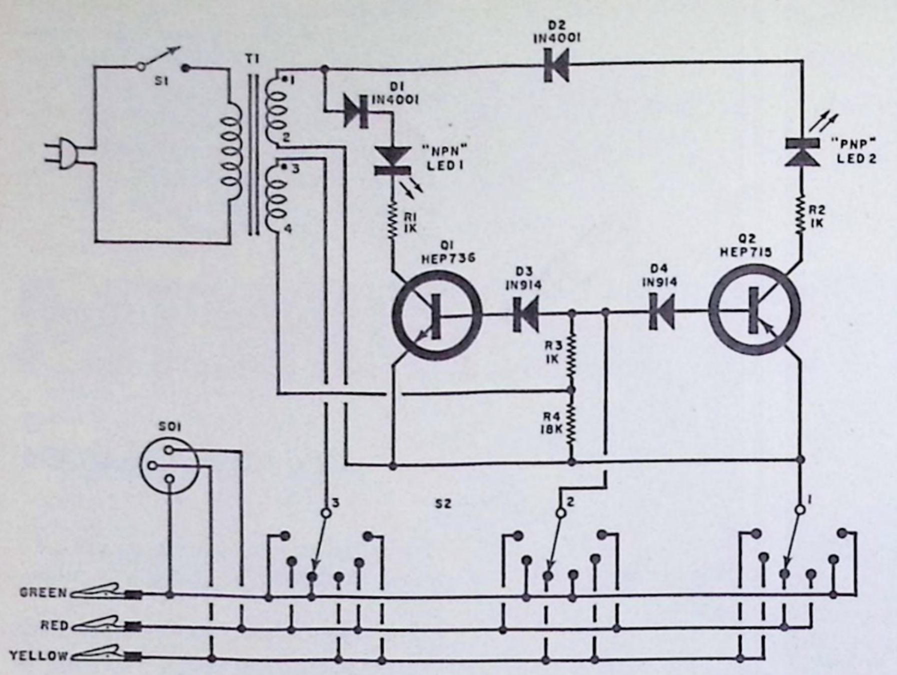
MOST experimenters have a drawer full of unidentified transistors which are of little use unless the leads and type (pnp or npn) can be determined. Actually, that's the only really important information needed to apply a transistor in a circuit—assuming it is "good" to begin with. Of course, it's nice to know what the transistor's beta is, but this is not essential in many applications.

The Identometer was designed to provide a quick check of a transistor's leads and type. It operates on the basis that bipolar transistors will operate, but poorly, if the emitter and collector leads are interchanged without also reversing the power supply. Since a transistor has three leads, it is possible to connect them in six different ways. With a transistor plugged into the test circuit, the Identometer has a switch to make the six different connections. When the right one is selected, an indicator light comes on. The light also tells whether the unit is npn or pnp.

Circuit Operation. A schematic of the circuit is shown in Fig. 1. Note that *T1* has two secondaries, one serving as the power supply for the *Q1-LED1* and *Q2-LED2* circuits and the other for the unknown transistor. Transistor *Q1* saturates when the upper secondary voltage is in the positive half cycle and its base is positive. Transistor *Q2* saturates when its collector has a negative voltage and its base is negative. The two transformer secondaries must be in phase as shown by the small dots at terminals 1 and 3.

The circuit is equivalent to an exclusive OR logic device, which has an output only when the two inputs are at different levels. The high or low signal requirements are provided by the transistor being tested and the instantaneous polarity of the ac line at the moment. The combination is one polarity for npn transistors and the opposite polarity for pnp types.




D2
1N4001
T1
S1
•1
2
•3
4
D1
1N4001
"NPN"
LED1
R1
1K
Q1
HEP736
D3
1N914
D4
1N914
Q2
HEP715
"PNP"
LED2
R2
1K
R3
1K
R4
18K
SO1
S2
3
2
1
GREEN
RED
YELLOW

PARTS LISTS

D1, D2—1N4001 diode
D3, D4—1N914 diode
LED1, LED2—Light-emitting diode (Calectro K4-559 or similar)
Q1—HEP736 transistor
Q2—HEP715 transistor
R1-R3—1000-ohm, ½-watt resistor
R4—18,000-ohm, ½-watt resistor
S1—Spst switch
S2—3-pole, 6-position rotary switch (Mallory 3236J or similar
SO1—Molded transistor socket
T1—12-volt, 300-mA filament transformer (Radio Shack 273-1385, modified per text)
Misc.—Plastic case (Radio Shack 270-231), Insulated miniature alligator clips (red, green, and yellow; Radio Shack 270-378), knob with pointer, line cord, mounting hardware, press-on type, etc.

Fig. 1. Transistor being tested is plugged into SO1 or connected to color-coded alligator clips.

This distinction provides the type identification.

With the correct phasing of the 3-4 secondary of *T1*, the exclusive OR signals are accepted by the LED driver that can react to a compatible signal during its half cycle of the ac. Diodes *D3* and *D4* prevent slight differences in the voltage levels from turning on the drivers.

Construction. To duplicate the prototype and use the pc boards shown in Fig. 2, certain mechanical modifications must be made to two of the components. Transformer *T1* must have its four terminals cut to a size that can fit into the pc board. As shown in Fig. 3, two more tabs must be added to terminate a new winding. The molded plastic form of this transformer allows adding the two new terminals (3 and 4 on the schematic). The six terminals will then be spaced three on each side, on ⅜-in. centers.

Wind 46 turns of #34 enamelled wire around the original core. There is enough room to do this, although it will take a little patience. Be sure that the new winding is wound in the same direction as the 12-volt winding already on the transformer to ensure correct phasing. (Don't scrape the enamel off the wire.) If you should wind the new secondary the wrong

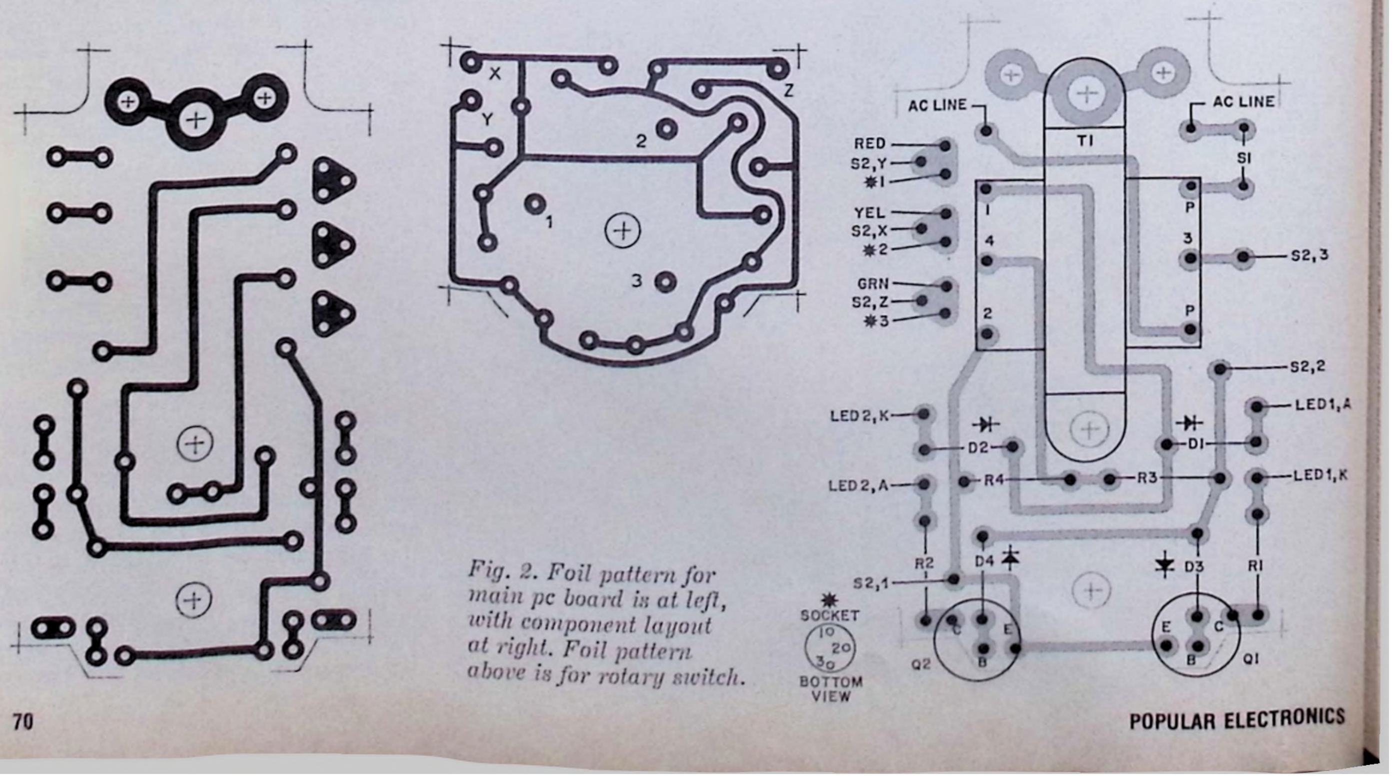

X
Y
Z
1
2
3
AC LINE
AC LINE
T1
S1
RED
S2,Y
✱1
YEL
S2,X
✱2
GRN
S2,Z
✱3
1
4
2
P
3
P
S2,3
S2,2
LED1,A
LED1,K
LED2,K
LED2,A
D2
D1
R4
R3
R2
D4
D3
R1
S2,1
C
E
B
Q2
Q1
✱
SOCKET
1
2
3
BOTTOM VIEW

Fig. 2. Foil pattern for main pc board is at left, with component layout at right. Foil pattern above is for rotary switch.

way, it is easier to route the ends to the correct terminals than to start over or modify the pc board.

The terminals of *S2* must be modified as shown in Fig. 3 so that the switch will fit the pc board as shown in Fig. 2.

Now you are ready to assemble the circuit on the main board as shown in Fig. 2. The front panel is marked as shown in the photograph with the six switch positions identified. Install *SO1* and mount the LED's in small rubber grommets, properly identified.

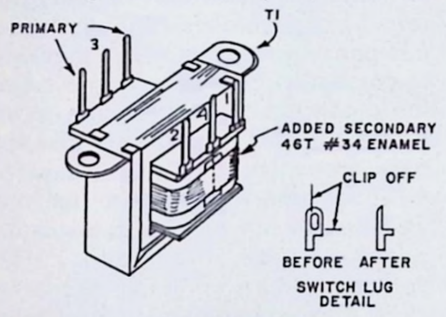


Fig. 3. Add a winding and terminals to the transformer and alter switch lugs as shown.

Then mount the switch on the front panel. Connect the larger board to it with spacers. Note that the large board has a small spacer supporting it from the hole drilled near the center of the rotary switch board.

Drill three small holes for the colored test leads and put grommets in the holes. The leads are terminated with color-coded insulated alligator clips. From the top of the panel, the lowest test lead (green) is on a line from the emitter terminal on *SO1*; the center lead (yellow) is the base; and the upper lead (red) is the collector.

Operation. Connect the three color-coded test leads to the unknown transistor in any order, turn on the power, and rotate *S1* until one of the LED's illuminates. Make sure that this only occurs at one position. The position of the switch will then identify the leads and the LED will indicate the type.

If the transistor being tested is not good (either open, shorted or leaky), neither indicator may come on or one or both may light at more than one switch setting.

The Identometer will not check FET's, nor will it work "in circuit." When checking power transistors, particularly germanium types, there may be some unpredictable results due to the high leakage current associated with these transistors. ◈

Simple Squelching Circuit for Stereo FM Tuners

BY LAWRENCE N. DWORSKY

MANY inexpensive stereo FM tuners have no automatic "squelch" to eliminate between-station hiss. However, they invariably have a stereo indicator lamp that can be used to trigger a very simple squelching circuit like that shown in the schematic.

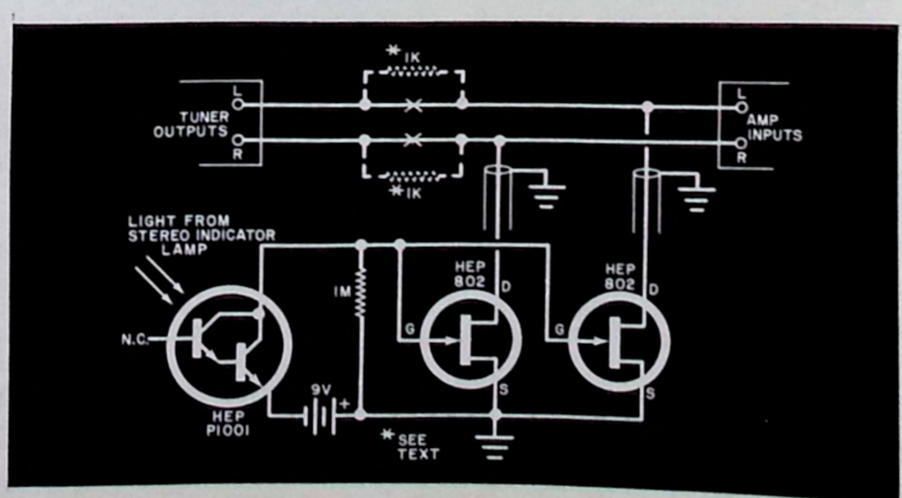
The add-on squelch circuit shown employs an inexpensive photo Darlington amplifier (HEP1001), operating with its base connection "floating". The Darlington amplifier switches from a very high resistance in darkness to a very low resistance when illuminated by relatively low light levels. When the photo transistor is switched to low resistance, essentially the supply voltage from the battery is applied across the gate-source terminals of both HEP 802 FET's. This pinches off the FET's and causes them to present a very high source-drain resistance across the outputs of the tuner, effectively doing nothing.

When there is no light present, the photo transistor presents a high resistance to the gates of the FET's. The source-drain resistance of the FET's therefore drops to about 200 ohms, effectively short-circuiting the outputs of the tuner.

If the tuner being used has an exceptionally low output impedance —less than 600 ohms or so—the between-station muting may be insufficient with this setup. In this case, a 100-ohm resistor placed in each output line of the tuner (see phantomed portion of schematic) should remedy the problem. Since most amplifiers have a relatively high input impedance, these resistors should have no effect on system performance.

No power switch is needed with the add-on squelch circuit because battery drain is very low. Even when operating at full capacity, the drain is less than 10 µA. So, the battery will last just about its shelf life with power continuously on, which eliminates the bother of having to remember to turn on an extra power switch.

When installing the squelch circuit, use only shielded audio cable to make the hookups between tuner, squelcher, and amplifier. Also, mount the Darlington amplifier as close as possible to the stereo indicator lamp in the tuner. This transistor is very sensitive; so, care must be taken to insure that it "sees" light from only the stereo indicator lamp and not from any other light sources. ◈



MAC'S SERVICE SHOP

LIGHTNING DAMAGE INSURANCE JOBS

By John T. Frye, W9EGV

"IT'S TIME we furthered your education by discussing lightning-damage insurance jobs that come into the shop," Mac announced to Barney his assistant, during their afternon Coke-break.

"A man can't even enjoy a Coke around here without having it laced with knowledge," the red-headed youth grumbled, "but go ahead—if you must."

"That's what I like: an enthusiastic listener," Mac said, lighting his pipe. "There are three entities involved in this kind of a job, and each must be considered: the owner of the damaged electronic equipment, his insurance company, and the service shop called upon to assess the nature and extent of the damage and possibly to repair it. Let's run quickly through the chronology of such a job; then we'll go back and discuss interesting features.

"First, an insured who thinks lightning has damaged his radio, TV, hi-fi, amateur station, CB transceiver, etc., should *promptly* report this to his insurance agent, who will instruct him to get an estimate of the damage from an established service shop. (That doesn't mean the insured's brother-in-law who tinkers around with electronics in his spare time!) At the shop, a technician carefully examines the equipment to see if the set failure was caused by lightning, the extent of the damage, and the probable cost of repairing the set. This information is relayed to the insurance agent, directly or through the owner, and the agent calls an adjuster to look at the set. It may be a few days before the adjuster calls at the shop; but when he does, he will want the technician to show him hard evidence that lightning did the damage; so all such evidence should be carefully preserved for his inspection.

"The adjuster reports to the insurance company, which, based on his recommendation, either (1) denies all responsibility due to a lack of evidence that the failure was caused by lightning, (2) authorizes a repair of the set, or (3) because the cost of repair is prohibitive, makes some cash or replacement arrangement with the insured. The company pays for the estimate in the last two cases; the customer pays in the first. At any rate, the bill is made out in triplicate: one for the customer, one for the insurance company, and one for our files. The customer pays us, and we give him two receipted copies of the bill. He turns one over to the insurance company, and they send him a check."

"Why might a person think lightning had damaged his equipment?"

"Such circumstantial evidence can vary all the way from a coincidence in which the set would not operate immediately after a heavy thunderstorm to much stronger evidence in which a ball of fire comes out of the TV set at the same time there is a snap of lightning from a nearby stroke, followed by smoke curling out the rear of the cabinet."

"That last reminds me of Thoreau's remark: 'Some circumstantial evidence is pretty strong, like finding a trout in the milk.' How does lightning usually reach the equipment?"

"In the case of a receiver attached to an outside antenna, the stroke or induced voltage surge can come in on the feedline, but more often it enters via the power line. A bolt doesn't have to strike the line for this to occur. All it has to do is strike in the vicinity. After all, the current of lightning strikes has been estimated to be as high as 200,000 amperes, with 15,000 to 20,000 amperes being an average value; and the voltages producing the strike are estimated to be as high as 100,000,000 volts. Lasting only microseconds, such a strike produces a tremendous field that induces a voltage surge on the primary of a power line that can leap across to a transformer secondary and enter the house through the ac wiring. This surge can easily bridge open switch contacts of a radio or TV receiver. Most people don't understand this.

"What kind of damage does lightning do?"

"Mark Twain remarked that one thing you could lie about and get away with was to tell something you heard a parrot say. Lightning stories are like that. No one can *prove* you're lying. I've seen lightning strike a horizontal antenna and reduce it to a line of little copper beads in the grass below. When a conductor carries a heavy current, forces are developed by the accompanying magnetic field that tend to crush the conductor. This is called the 'pinch' effect. Another time I saw a rubber-covered copper wire that had been hit by lightning and reduced to a rubber tube with no wire inside at all. Stranger still, the rubber insulation seemed to be intact and hardly scorched. More common effects include the fragmentation of line bypass capacitors, melted power switch contacts, fused conductors on pc boards, vacuum tube envelopes shattered, ruptured filter capacitors, shorted windings in power transformers, antenna input coils of radios and TV sets badly charred, flash burns on the chassis in the vicinity of line cord tie-points or the power switch, and tubes with burned out filaments. These are some of the things the adjuster will expect to see."

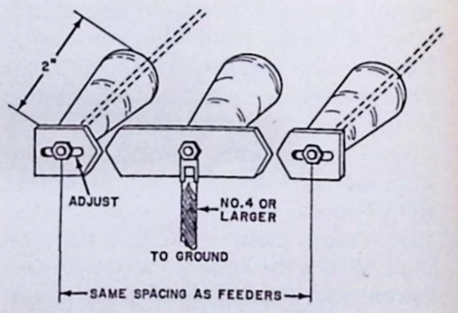


Fig. 1. A spark gap arrestor to protect ham antenna is easily made.

"I imagine the action the insurance company takes depends a lot on the policy the owner has."

"Right. The usual home owner's policy comes in a variety of types, including various deductible amounts with matching premiums. Naturally, the higher the deductible the lower the premium. TV, amateur, and CB antennas, rotators, and towers are not ordinarily covered by policies that are written to cover the house, garage, and household goods. Even then, with ch a policy, TV sets, radios, and i-fi's are only covered for their actual ash value. The guy who has never ead his policy carefully may be very hagrined to discover the total loss of his beloved but ten-year-old hi-fi does not entitle him to a brand-new stereo system at the expense of the insurance company. He may do well to recover the cost of a new stereo cartridge.

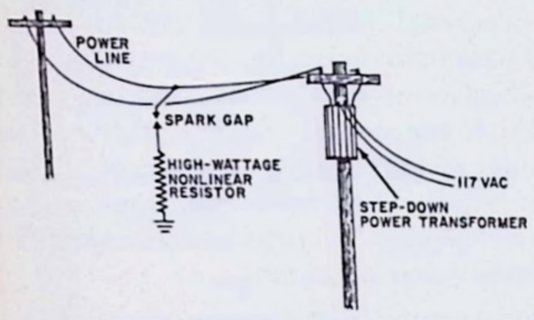


Fig. 2. In power-line arrestor, current is reduced by resistor.

"But there's another way to go. If he has ham, CB, or hi-fi equipment worth $500 or more, he can insure it for full replacement value with a separate policy usually labeled a 'personal line floater' or an 'inland marine floater.' Then, if his equipment is destroyed, the company will pay enough to buy a new system comparable to the one he had before. Such policies cost from 80¢ to better than $2 per $100 of declared value per year, depending on the individual company and the item insured. Jewelry, cameras, tools, service instruments, and similar equipment in the home can be insured with these policies."

"Seems to me the technician is pretty important in this operation."

That he is. Actually I do many insurance jobs here without ever seeing an adjuster. Local agents know me, and they also know the average adjuster is unqualified to assess damage to sophisticated electronic equipment. They're content to use my report as the basis for settling the claim. I'm sure this arrangement prevails in many other communities, and it puts a lot of responsibility on the technician, especially when the equipment belongs to a long-standing customer who feels 'taking' an insurance company isn't really stealing. When one of these starts hinting he wants me to declare his equipment a total loss when it isn't, or to say the damage was caused by lighning when there's no evidence to support this, I suggest that he take his set to another shop because I intend to call things exactly as I see them. Invariably, he then backs off."

"What do you think is the best insurance policy?"

"That's easy: prevention. You rarely recover your entire loss through insurance; so the best thing to do is try to protect your equipment from lightning damage. You could, of course, follow the practice observed in the old French provinces and keep some wood from a lightning-struck tree under your bed, secure in the belief you're fully protected because 'lightning never strikes twice in the same place'; but I'd suggest you employ more scientific methods. Start by making sure your house wiring is properly grounded and protected against overloads with fuses or circuit breakers. Install U.L.-approved arrestors on all TV lead-ins, antenna rotator control wires, and coax feed lines. Ground metal towers or metal masts mounted on poles or other wooden supports. Make a *good* common ground. If you don't know how—most people don't—order "Lightning Protection Code 1968," NFPA No. 78, from the National Fire Protection Association, 470 Atlantic Avenue, Boston, MA 02210, for a postpaid price of $1.37."

"How do lightning arrestors work?"

"There are many types, but all are intended to do one job: carry a heavy surge of lightning-induced current in a conductor safely to ground, while leaving that conductor virtually disconnected from ground at all other times. Let me sketch a couple of common types. Shown in Fig. 1 is a homemade spark gap arrestor for use on the open-wire feeders of a ham antenna. Gaps are spaced just wide enough not to arc with full power from the transmitter, but voltage from a nearby discharge will start the arc that carries the heavy current safely to ground. When the surge subsides, the arc stops.

"Things are different when the conductor normally carries heavy current and high voltage, as does a power line primary. Once the arc is started by lightning, the follow-current from the generator would keep it going until the arc electrodes were melted. The arrangement in Fig. 2 prevents this. The nonlinear thyrite resistor has a resistance which decreases exponentially with increasing current. When carrying the heavy discharge current, it is a virtual shortcircuit; but with the lower follow-current, the resistance increases until the voltage drop across it is sufficient to stop the arc. Various resistance and gap types of lightning arrestors are manufactured for use with telephone lines, coaxial cable, twin-lead, etc.

"But remember I said most damage from lightning occurs when a surge comes in on the house wiring. That's why I think it is an excellent idea to install a secondary service lightning arrestor, such as G.E. Model 9L15CCB007, called a Home Lightning Protector, right at the service entrance. Otherwise, pull the plugs on all electronic equipment when you're going to be gone for several days or when you're home and a thunderstorm is building."

"Do you think a high antenna tower invites lightning damage to the home?"

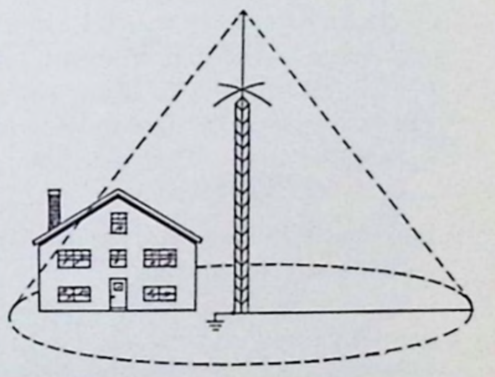


Fig. 3. A metal antenna tower, properly grounded, provides a cone of protection for the house.

"Quite to the contrary, if the tower is metal and properly grounded or has the metal mast properly grounded, it actually provides a cone of protection as shown in Fig. 3. Note that the apex of the cone is at the top of the grounded antenna, and the radius of the base is equal to the height of the tower. A direct strike of lightning to any object inside this cone is very unlikely."

"All right, let's recapitulate: quiz your insurance agent and read your policy carefully to see exactly what kind of protection you have for your electronic equipment. To protect that equipment, use lightning arrestors on all leads entering the house, including the power leads. Make good grounds and bond them together. Pull plugs during storms or when you're going to be away from home, and don't try to con the service technician into helping you defraud the insurance company. If he goes along with that, he'll cheat you, too!" ◆

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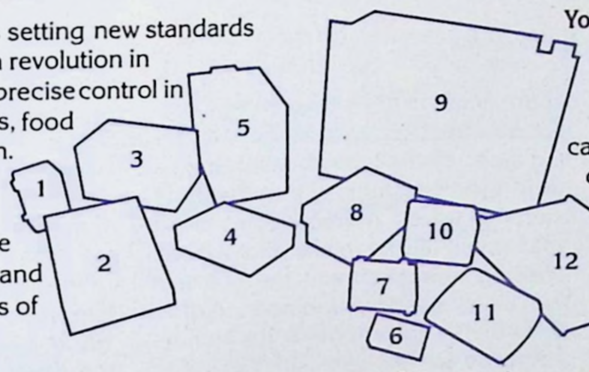

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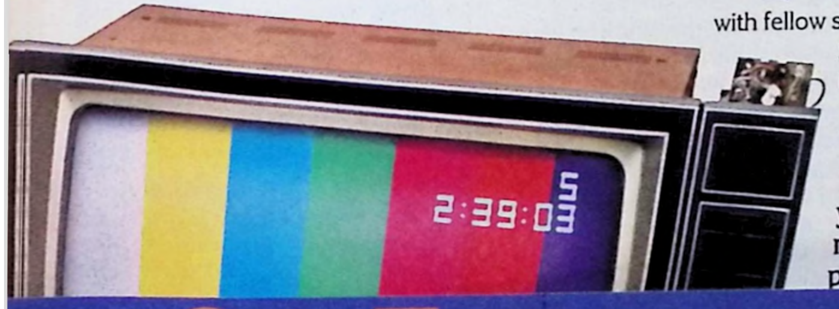

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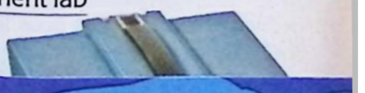

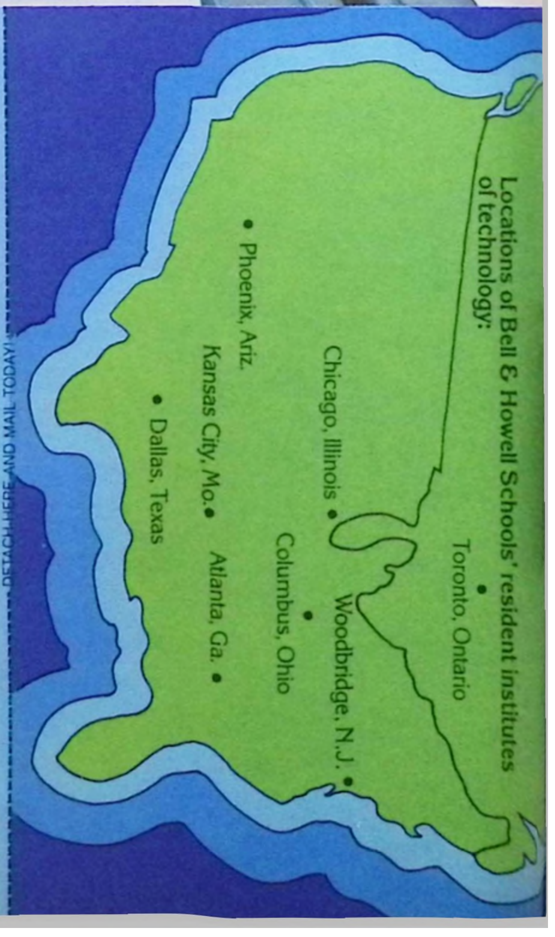

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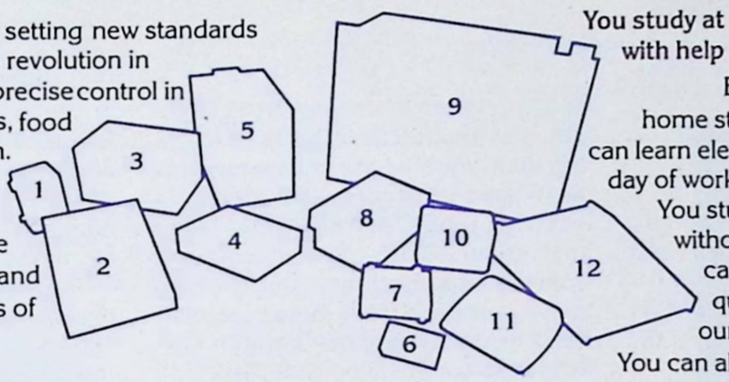

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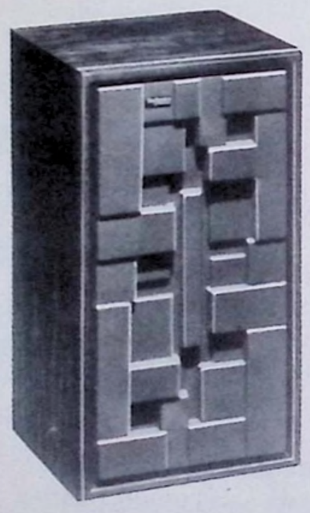
Product Test Reports

TECHNICS BY PANASONIC MODEL T-200 SPEAKER SYSTEM

(A Hirsch-Houck Labs Report)

Compact, inexpensive system with room-filling sound.



THE Technics Model T-200 is the least expensive of a new series of loudspeaker systems from Panasonic. It is a compact system that measures 21 ¾ in. by 12 in. by 10½ in. deep (55.2 × 30.5 × 26.7 cm) and weighs slightly less than 30 lb (13.6 kg). The oiled walnut cabinet contrasts with an attractive sculptured, acoustically transparent grille that is available in either blue or brown.

The two-way system contains a 10-in. (25.4-cm) acoustic-suspension woofer that crosses over at 1800 Hz to a 1¾-in. (4.45-cm) cone-type tweeter. The rated dispersion angle of the tweeter is 120° in both the horizontal and vertical planes. A switch is provided on the rear of the cabinet to permit the tweeter level to be set for normal or 3 dB attenuation. (Flattest overall response is obtained with maximum tweeter output.) The system has a rated nominal impedance of 8 ohms.

The retail price of the Technics Model T-200 speaker system is $99.95.

Laboratory Measurements. The response of the speaker system was measured in a "normal" listening room by a method that yields a good approximation of its total energy output over the frequency range. Averaging and warble-tone measurements were used to minimize the effects of standing waves. At frequencies lower than about 300 Hz, close microphone spacing was used, and the two test curves obtained were joined together to provide a composite frequency-response curve.

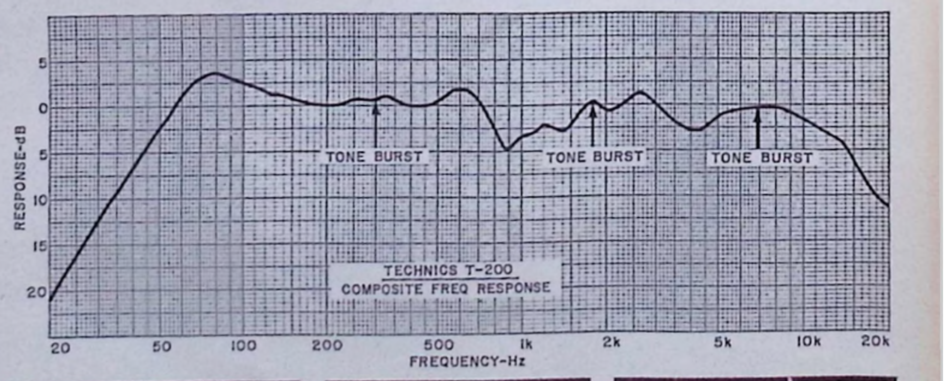
The response of the woofer was notably smooth, with a resonant peak of about 3.5 dB at 75 Hz and no sign of irregularity up to several hundred hertz. The tweeter also had a rather flat response curve (although it is normal to find some irregularity at high frequencies with the measurement methods we used). Its output fell off smoothly at frequencies beyond 10,000 Hz, with no sign of a peak throughout its entire range. The overall response was a very good ±4 dB from 45 Hz to 14,000 Hz.

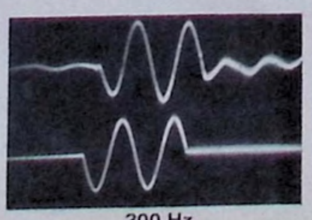
The bass distortion at a constant 1-watt drive level was between 3% and 5% from 100 Hz to 60 Hz. When we varied the drive level to maintain a constant 90-dB sound-pressure level (SPL) at a distance of 1 meter from the woofer, the distortion was somewhat higher than we have measured on some other speakers of the same size, but it was not audible on program material.

The tone-burst response was fairly good. There were no signs of severe ringing or generation of spurious frequencies throughout the operating range of the system. Efficiency was moderately low, as would be expected of an acoustic-suspension design. An input of 1 watt in the midrange produced a 90-dB SPL at a 1-meter distance. This corresponds to about 80-dB SPL in the normal listening area of a typical room, which is about as loud as most people would care to listen to music in their homes.

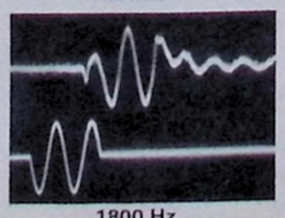
The electrical impedance of the system was 5 ohms at 20 HZ and between 100 and 200 Hz. It peaked at 18 ohms at the 62-Hz bass resonance point. At frequencies higher than 1000 Hz, the impedance was typically 15 to 18 ohms.

User Comment. The general shape of the measured response curve for the T-200 was confirmed by our simulated live-versus-recorded listening test in which the T-200 was used to imitate the sound of a specially recorded program played through a reference speaker, our "live" orchestra. The T-200's midrange and highs were virtually perfect, but there was a slightly full quality in the lower midrange and upper bass range. This appeared to correspond with the fact

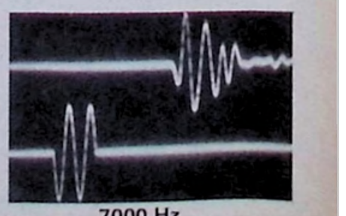




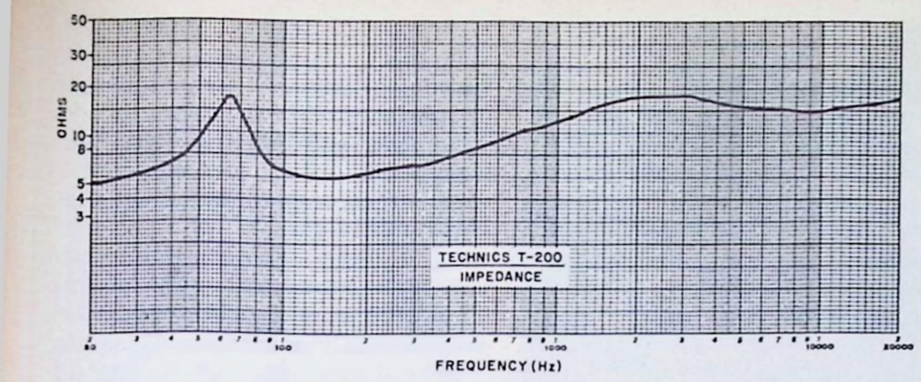
300 Hz



1800 Hz



7000 Hz



that the average woofer level was a few decibels higher than was the average tweeter level.

When a 3- to 4-dB attenuation (a "shelf" response cut) was applied at frequencies below 1000 Hz with an octave-band equalizer, the speaker system did a near-perfect job of imitating the original sound in an A-B comparison. The highs were obviously peak-free and very well dispersed.

Listening to this speaker system, one is apt to find it difficult to believe that the sound is coming from an inexpensive compact system. It gives a room-filling sound suggestive of a much larger system and provides exceptionally good musical balance and overall smoothness. The T-200 illustrates most effectively how the proper combination of conventional drivers and crossover components by a knowledgeable designer can produce a total sound character that is greater than the sum of its parts.

CIRCLE NO. 65 ON READER SERVICE CARD

PIONEER MODEL RT-1011L STEREO TAPE RECORDER
(A Hirsch-Houck Labs Report)

Logic-controlled recorder handles 10½-inch reels.

PIONEER
PIONEER

THE U.S. Pioneer Electronics Model RT-1011L stereo tape recorder features three motors, three heads, solenoid-operated transport, and 7½ and 3¾ ips (19.05 and 9.53 cm/s) operating speeds. This quarter-track recorder is designed to accommodate tape reels measuring up to 10½ in. (26.7 cm) in diameter. The transport is "logic controlled" so that any operating mode or speed can be selected from any other without having to first press the STOP button. Yet, the tape is fully protected against breakage and spilling.

General Description. The recorder's tape loading procedure is simplified by a guide roller arm that locks out of the way when it is moved to its limit so that the tape takes a straight-line path across the heads, over the capstan, and over a tensioning arm as it goes to the take-up reel. The tensioning arm also serves as an automatic shut-off switch in the event of tape breakage and when the tape runs out.

Two large illuminated meters indicate both recording and playback levels. The meters monitor the line outputs so that the playback indications vary with the setting of the playback level controls. Located above the meters is a red light that comes on whenever one or both channels is set to the RECORD mode. Below each meter is a standard jack for 600- to 50,000-ohm dynamic microphones.

Locking pushbutton switches control ac power, tape tensioning for 7-in. (17.8-cm) and 10½-in. (26.7-cm) tape reels, and tape speed. Other pushbuttons are labeled REC, PLAY, REWIND, FAST FORWARD, and STOP. For easy identification, the REC button is red, while the STOP button is larger than the others. Although the pushbuttons energize solenoids, they are designed to mechanically lock into position to permit the recorder to be set up in advance for recording. When line power is later applied by an external clock timer, the deck goes directly into its recording mode.

Five lever switches supplement the pushbuttons. Two place the channels individually into the recording mode when the REC button is pressed. This is a safety feature that prevents accidental tape erasure. It also serves as a means of recording on one channel while playing back through the other for echo and sound-on-sound (the latter requiring external patching).

Two more levers provide exceptional flexibility in adapting the recorder to any type of tape. They separately control recording bias and equalization. Each has positions for STD (standard) and LH (low noise/high-output) tape formulations. A table in the comprehensive instruction manual provided with the recorder suggests switch setting combinations for many popular tapes. Alternatively, optimum conditions can be determined by recording and listening.

The last lever switch connects the line outputs to either the source (input) signal or to the playback amplifier's outputs.

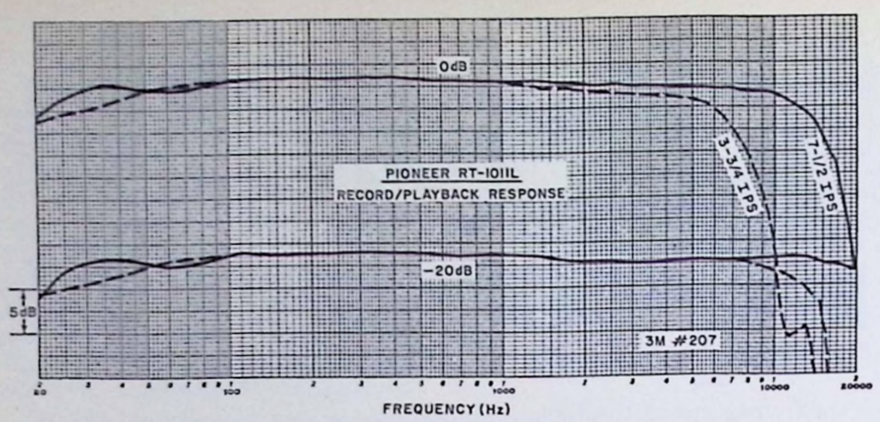
Concentric control knobs are provided for independently adjusting the recording levels in the two channels. One pair of controls is for the microphone inputs, while the other is for the line inputs. A third pair of concentric controls permits the playback level to be adjusted in each channel.

A stereo headphone jack is located on the recorder's front panel. The line inputs and outputs and a DIN socket that repeats the two are located on the rear of the recorder.

The recorder can be operated vertically or horizontally. It measures 17 in. high by 16 7/8 in. wide by 8 15/16 in. deep (43.2 × 42.9 × 22.9 cm) and weighs 49 lb (22.3 kg). It comes with walnut side panels, a 10½-in. metal reel, and two reel-hub adapters for professional-size reels with large center holes.

The retail price of the Pioneer Model RT-1011L stereo tape recorder is $599.95.

Laboratory Measurements. Using Ampex test tapes, we found the playback equalization of the tape re-



corder to be very accurate at both speeds. It was within ±0.5 dB from 50 Hz to 15,000 Hz at 7½ ips and within ±0.8 dB from 50 Hz to 7500 Hz at 3 ¾ ips. (These are the frequency limits of the test tapes.)

We used 3M No. 207 tape for the balance of our tests. We measured the record/playback response with all four combinations of switch settings. Although the differences were slight, we concluded that the LH bias and STD equalization settings yielded the flattest overall frequency response.

Using a -20-dB recording level at 3 ¾ ips, the overall response was within ±2.5 dB from 20 Hz to 13,500 Hz. At a 0-dB recording level, tape saturation (expected at this speed) caused a sharp drop-off in response beyond 7000 Hz. At 7½ ips, the response at the –20 dB level was a very flat 2.5 dB from 20 Hz to 24,500 Hz. It was within ±1 dB from 25 Hz to 21,000 Hz. Saturation was less of a problem at higher recording levels at 7½ ips. Hence, the 0-dB response did not begin to fall off appreciably until we reached 12,000 Hz.

The line inputs required 43 mV for a 0-dB recording level. This produced a maximum playback output of 0.5 volt. The microphone sensitivity was 0.18 mV for 0 dB, while the amplifiers overloaded at 70 mV. This should be quite adequate for most recording situations.

A standard Dolby level tape played back with a full-scale +3-dB meter indication. The meters were somewhat slower in responding than are true VU meters. They indicated 65% of their steady-state values on 0.3-second tone bursts as compared to 99% for a true VU meter.

At a 0-dB recording level, the playback distortion was 1.0% at 7½ ips and 1.2% at 3¾ ips. To reach the standard 3% reference distortion level, it was necessary to record at +12 dB (far off the meter scales) at either tape speed. Referred to this level, the unweighted noise was -62 dB at 7½ ips. With IEC A weighting for better correlation with subjective effects, the noise was -70.5 dB. It is interesting to note that the S/N ratio at 3¾ ips was only 0.5 dB lower than at 7½ ips. At maximum gain through the microphone inputs, the noise level increased by a negligible 3 dB.

The tape speeds were 0.4% fast at 7½ ips and 0.4% at 3¾ ips. In fast forward and rewind, an 1800-ft (550-m) tape passed in 84 seconds. The unweighted rms flutter was 0.12% at 7½ ips and 0.16% at 3¾ ips. To our surprise, the flutter was reduced when the guide roller arm was locked in its loading position. (It normally plays an important part in reducing flutter.) The flutter measurements were then 0.08% and 0.12% respectively. Wow was the residual of the test tapes, measuring 0.01% to 0.02%.

The tape transport operated smoothly and appeared to be foolproof. When going from either fast speed to PLAY, the tape came to a stop in about a second and paused for 2 or 3 seconds before going into play. The manual explains how the PAUSE control can be used to eliminate even this small delay if desired.

The headphone outputs had very good volume levels, even with 200-ohm high-impedance phones.

User Comment. Despite an ability to accommodate 10½-in. reels, this is very much a home tape recorder—an outstandingly fine one. In ease of loading and handling, it is about as simple and straightforward as any machine we have used. Its frequency response, distortion, and noise levels are among the best we have measured and would do justice in most respects to any professional recorder.

Due to the calibration of the deck's meters, it is eminently practical to maintain average music recording levels near the 0-dB mark. The meter pointers can be permitted to swing to full-scale and beyond on peaks without serious risk of over-recording.

Needless to say, the deck did a flawless job of recording from phonograph and tuner sources as well as of playing back commercially recorded tapes. At a surprisingly reasonable price, the Pioneer Model RT-1011L offers an impressive combination of high performance and operating versatility.

CIRCLE NO. 66 ON READER SERVICE CARD

HEWLETT-PACKARD MODEL 5381A FREQUENCY COUNTER

Seven-digit, laboratory-grade instrument operates to 80 MHz

WITH the increasing number of frequency sensitive circuits in modern electronic systems—filters in stereo receivers and speaker crossovers; SSB, RTTY, and SSTV filters in ham gear; digital systems in frequency synthesizers and calculators—a good frequency counter is an important item to have on the electronics workbench. A frequency counter is essential for checking the accuracy of dials on r-f and a-f signal generators. Though they are usually "within the ball park," dial accuracy and resetability are more critical when complex filters are involved since they don't work properly unless they are tuned "on the head."

Although there are many reliable frequency counters, it is nice to see that one more big name (Hewlett-Packard) has entered the relatively low-cost market with their Model 5381A Frequency Counter ($249).

This 7-digit (LED) laboratory-grade instrument has a frequency range of 10 Hz to 80 MHz (which means it can be used in the CB and ham ranges).

Sensitivity is 25 mV up to 20 MHz and 50 mV to 80 MHz. Accuracy is ±1 count plus or minus the time-base accuracy. The time base uses a 1-MHz crystal that ages less than 0.3 ppm/month, ±10 ppm from 0° to 40°C, and ±1 ppm for a 10% line voltage variation.

Gate times can be selected manually and the resolution is 10 Hz at the 0.1-second gate time, 1 Hz at the 1-second gate time and 0.1 Hz at the 10-second gate time. The input impedance is 1 megohm shunted by 50 pF. Even at the most sensitive settings, the input to the counter will handle up to 200 volts (peaks ac plus dc) without harm.

Physically, the 5381A is quite pleasing in appearance, with a clean, uncluttered look. It is 3.5". high, 6.25" wide, and 9.75" deep. It weighs 4.75 lb and has a built-in tilt stand.

User Comment. We had the opportunity of using the 5381A for several weeks on a variety of electronic equipment. After aligning a number of SCA traps and half a dozen or so filters in SSB and SSTV rigs, and checking a number of countdown circuits in digital projects, we really got to like the look of the seven-digit, easy-to-read display. In the MHz mode, reading the value down to three decimal places was easy, while in the Hz mode, resolution was 0.1 Hz.

The 5381A was in regular use in the shop even through the so-called "brownout" days when the power line had considerable variations. We did not have to worry about the accurate settings on the various frequency generators since the excellent accuracy of the 5381A, even with 5% to 8% power reductions, enabled us to make critical adjustments.

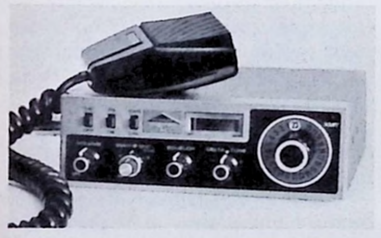
A number of CB rigs have been checked and aligned with each other, after which, communication between units was improved due to the closer r-f alignment. The tone-alert accessories were also re-aligned so that the systems worked as they did when brand new.

For use at even higher frequencies, Hewlett-Packard also has a Model 5382A, a 225-MHz version, which costs $450.

CIRCLE NO. 67 ON READER SERVICE CARD

TRAM DIAMOND 40 AM CB TRANSCEIVER

Has output circuit protection, SWR bridge and noise blanker



THE Tram Diamond 40 is a 23-channel crystal-synthesized mobile transceiver designed for AM operation on the Citizens Band. Among its special features are a microphone-gain control, final-amplifier protection circuitry, built-in SWR bridge, switchable noise blanker (in addition to the usual AM-type noise limiter), and a theft-deterrent mobile mounting bracket. An edgewise meter movement indicates relative signal strength on receive and relative output power or SWR on transmit. Also included are the usual adjustable squelch, Delta tune, public-address facility, and detachable microphone.

The transmitter operates at full legal power when the transceiver is connected to a nominal 13.8-volt dc power source. The power source can be either a positive- or a negative-ground system. Reverse-polarity protection is provided in either case. Stability of critical circuits under varying source voltages is assured by means of a built-in electronic voltage regulator.

The transceiver measures 8 in. by 6¾ in. by 2½ in. (20.3 × 17.1 × 6.4 cm) and weighs 6 pounds (2.7 kg). It retails for $209.95.

The Receiver. According to our tests, the double-tuned receiver has excellent sensitivity and selectivity. The sensitivity measured 0.3 µV for 10 dB (S + N)/N at 30% modulation and 1000 Hz. Adjacent-channel rejection was nominally 60 dB, while good communication quality was maintained with a 6-dB overall bandpass of 450 to 2400 Hz.

The bipolar r-f input amplifier is equipped with shunt diodes that serve as protection against overloads. The first conversion to a 10.0- to 10.04-MHz i-f is accomplished with the aid of a FET mixer. A bipolar-transistor mixer is used for the second conversion to a 455-kHz i-f. Selectivity is obtained by using a ceramic-filter bypass at the emitter of the second mixer and a ceramic filter at the input of the two-stage 455-kHz i-f section.

Application of dual agc voltages to the r-f stage, plus a single loop to the second mixer, provides an exceptionally flat output response level. Only a 4-dB output change occurred with a 20-dB input signal variation (at 1-10 µV). A 3-dB change occurred with a 60-dB input change (at 10-10,000 µV), and a 6-dB change with an input excursion of 80 dB (at 10-100,000 µV). Approximately 50 µV of input signal was needed to register S9 on the meter.

Other measurements indicated an 80-dB rejection of the primary image and 70 and 90 dB i-f signal rejection at 10-10.04 MHz and 455 kHz, respectively. Spurious-signal rejection measured 55 dB minimum.

The noise blanker is a parallel-gate setup in which an IC is used at the front end and for gating the output of the second mixer. It can be turned on and off while simultaneously shifting in and out of the circuit a series-gate type a-f automatic noise limiter (anl). This noise-reducing setup proved to be extremely effective. It attenuated noise pulses of 30 to 40 dB above a 0.25 µV signal down to near inaudibility in the presence of the signal. Its use drops the overall gain on weak signals by 4 to 6 dB, but the sensitivity-versus-S/N ratio is unaffected.

(A noise limiter is simply an audio-frequency signal peak clipper. Usually set to provide 100% modulation, it clips any signal level that exceeds that required for full modulation. The blanker, on the other hand, interrupts the r-f signal path momentarily during high-level noise pulses ahead of the selectivity circuits. A limiter is a simple device that operates well enough, but because of its clipping action can cause a-f signal distortion when clipping takes place. The blanker is more sophisticated, operating only for short noise-signal durations. Because it interrupts the signal path, it is not distortion producing.)

The push-pull class-B output amplifier is driven by an IC. In our tests, it delivered a 3.5-watt output at 5.5% distortion at the onset of clipping with a 1000-Hz test signal. With clipping, the output was 4.5 watts at 10% distortion. A thermistor-compensated squelch was adjustable for thresholds of from 0.25 to 300 μV.

Frequency Synthesizer. The crystal frequency synthesizer in the Diamond 40 employs six crystals in the 16.965- to 17.215-MHz range. Four of the crystals are cut for the 9.545- to 9.585-MHz range for the receiver and four are cut for the 10.0- to 10.04-MHz range for the transmitter. During transmit, the frequency tolerance held to within 440 Hz on any channel.

The Delta-tune circuit for the receiver is detented at its center position, allowing the CB'er to "feel" when it is set to the middle of the channel.

The Transmitter. A triple-tuned bandpass-coupling network minimizes spurious responses from the synthesizer mixer for the transmitter. The r-f power output amplifier employs a triple-tuned output-matching section. Collector-modulation of the driver stage and power amplifier is accomplished with the receiver's a-f setup plus a speech amplifier for the mike. (The latter is automatically switched in for this mode.)

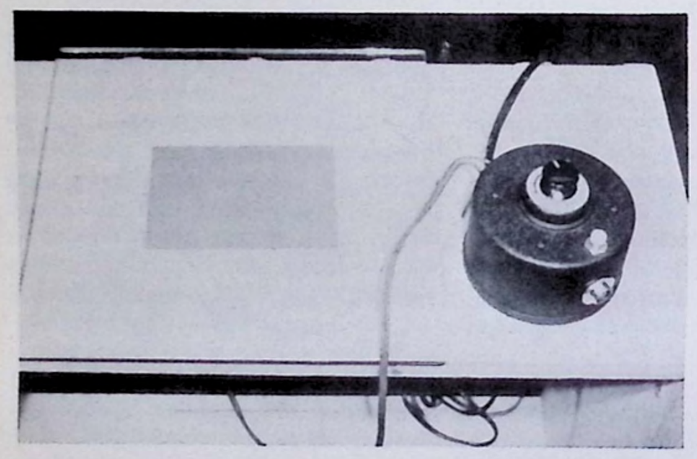
With operation from a 13.8-volt source the r-f carrier output measured 4.5 watts. The distortion measured 9% at 100% modulation at 1000 Hz, and the frequency response was 270 to 2700 Hz at the 6-dB points. Adjacent-channel splatter, using a 2500-Hz standard EIA test tone, was -50 dB. Advancing the mike gain control for an additional 6-dB input-signal level (a practice the operating manual advises against) caused clipping and increased the adjacent-channel splatter to -40 dB. With speech at normal modulating levels, the splatter was somewhat less. Setting the gain control to the point where the modulation starts to make the transmitter-on lamp blink slightly will usually hold the modulation within acceptably safe limits.

The fail-safe setup in the transmitter functions as follows: If the antenna line is badly mismatched to the transmitter, the resulting SWR will produce a large reflected voltage from the SWR bridge. This voltage is then used to disable the transmitter drive and thus protect the output transistor from damage under improper load conditions. This is a protective scheme we would like to see more of in transmitters.

CIRCLE NO. 68 ON READER SERVICE CARD

EDMUND SCIENTIFIC KIRLIAN ELECTROPHOTOGRAPHY KIT

Experimental photography provides fascinating results.



Electrophotography kit is set up on top of carton in which it is received.

PHOTOGRAPHY with electricity goes back to the 19th century. But it wasn't until Czechoslovakian researchers in 1939 published "electrophotographs" of leaves displaying strong corona patterns that some interest in the field emerged. It was the Russian scientists, the Kirlians, however, who truly developed the method in depth over the years, creating a wide range of patented apparatus for use in various fields.

Kirlian photography permits one to view brilliant emanations from organic or inorganic objects, made visible photographically only when the subject is placed in a field of high-frequency electrical currents. Using color film, the images are spectacular, revealing all colors, shades, patterns and degrees of brilliance. Some observers describe it as a pulsing energy source. Scientific interest revolves around interpreting the corona or "bio-energy" force, which displays changes as a result of anger, illness, or fear in a human; lack of water in a plant; etc.

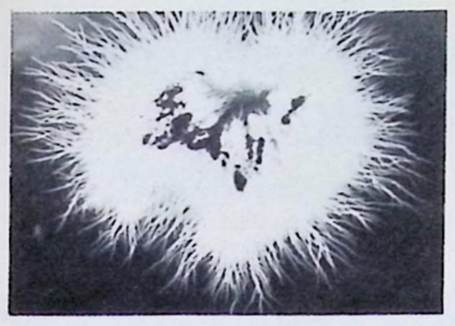
The Edmund Scientific Company's "Kirlian" Electrophotography Kit (No. 71,938) at $49.95 uses the principle described, opening up a new world of photography for experimenters.

What It Is. Edmund's "Kirlian" photography kit consists of a variable low-voltage transformer; a high-voltage, high-frequency induction coil; metal electrode; glass plate; photo changing bag; and all necessary lead wire. Calling it a kit is really a misnomer, as one does not truly "build" it. For example, the variable voltage step-down transformer and the high-frequency induction coil are fully assembled. What one does is set up the system from assembled components.

The high-quality step-down transformer, which is plugged into a 117-V ac source, provides output voltages that can be varied from three to eight volts. It includes an on-off switch. The high-frequency induction coil, which is fed the step-down transformer's low ac voltage, converts the voltage to a high-frequency, high-voltage output. High frequencies are developed by a set of vibrating contacts that interrupt the input at a rapid rate. Though output voltage from the induction coil is very high, the secondary's output current is quite low, being limited by core saturation. Nonetheless, great care should be taken when operating the device to avoid a shock.

Setting up the "Kirlian" kit is simple enough. Assuming a suitable darkened room for photographic developing purposes, here are the assembly steps: The cardboard shipping container is used as a support for setting up, folding one side's flaps inside and poking a pencil-size hole in the closed bottom to pass the high-voltage lead. Placing the high-voltage induction coil inside the carton, the high-voltage lead is pulled through the hole so that it protrudes from the carton. Now the carton is resting on its open side, the closed top acting as a platform with the electrode lead protruding.

The twin power leads of the induction coil are brought out from the bottom edge of the carton and plugged into the jacks of the variable low-voltage step-down transformer that is positioned outside the carton. Stripping about one inch of insulation from the high-voltage lead protruding from the carton top, the lead is bent 90 degrees, with the excess wire pushed back into the carton. The square, metal electrode is then placed on top of the HV electrode lead and the perimeter of the metal is taped to the carton with masking tape. Next, the glass dielectric plate is centered atop the electrode and taped down.


Kirlian photograph of a begonia leaf showing the corona around the edge.

If a suitable darkroom is not available, the photo changing bag should be used. Here, a hole is poked through the bottom to accommodate the high-voltage lead. The lead plus components on top are placed inside the bag, with the bag and its contents resting on the carton.

Completing setup, the following tests should be made before photographing an object. The stepdown transformer control should be set to its maximum, eight volts. Powering the device, you should hear "buzzing" of the interrupter contacts of the high-frequency coil. Next, the user's hand should be placed on the glass dielectric plate. The result should be a slight tingling sensation due to capacitive coupling of the high-frequency current. In the dark, a corona discharge should be seen from your hand; maybe, a crackling sound heard. (**Caution:** Do not operate equipment if the glass dielectric plate is damaged; limit skin area exposures to about one minute per day; use in a well ventilated area to prevent ozone buildup; use a pair of glass-lensed sunglasses when viewing the corona so that shortwave ultraviolet rays won't cause eye irritation; do not operate in the presence of anyone with implanted devices such as heart pacers or around children or anyone not familiar with normal electrical safety precautions.)

Either 35-mm film or Polaroid 4 x 5 sheet film type 58, may be used. The film is placed directly on the glass dielectric plate, centering it over the metal electrode under the glass. The emulsion side is placed face up. An object to be photographed "Kirlian" style is placed directly on the film. For small objects, such as a coin, one's finger is placed on the object to provide a ground.

Comments. Setting up the Edmund Kirlian Photography Kit was an easy job. But in our haste we did not follow directions to tape down the glass dielectric. After using the system a while, the glass moved, which allowed an associate to be jolted by a discharge. With the glass covering the metal electrode, however, only a mild tingling sensation was felt. Following this, we taped down the hot lead and wiped the glass on both sides to be sure that moisture and dirt would not provide an electrical path.

We used black-and-white sheet film (ASA 32), taping it to the glass. However, 35-mm film, black-and-white or color, can be used. For the latter, the cassette should be taped close to the edge of the glass, securing the leader to a bulk-film reloading 35 mm cassette, which is taped to the opposite end of the glass. Using a 3/8" wood dowel as a handle, tapering the end to fit the bulk-film cassette, five clockwise turns of the spool (done in the dark) will withdraw sufficient unexposed film.

A user must experiment with exposure. Recommendations by the manufacturer are a fair guide, but best exposure varies due to humidity, film dampness, object density, etc. Typical exposures will be 12 to 15 seconds when the voltage control is set at eight. We started at six volts, feeling that there's more control over exposure if time is a bit longer.

There's no doubt that "Kirlian" photography is fun. You'll be amazed at the results, especially with color film. Edmund Scientific also has a $9.95 starter kit and a more expensive "professional" kit. The former uses a piezoelectric demonstrator.

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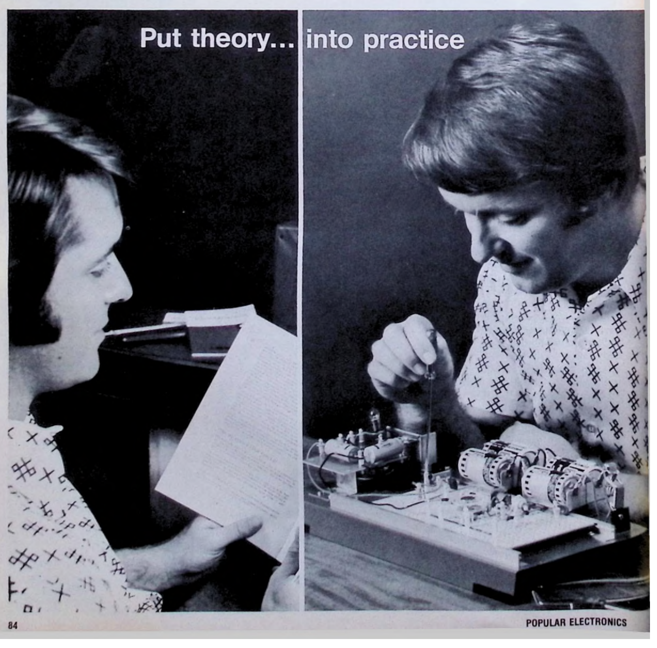

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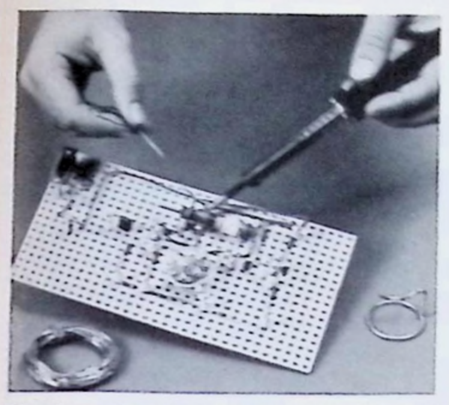

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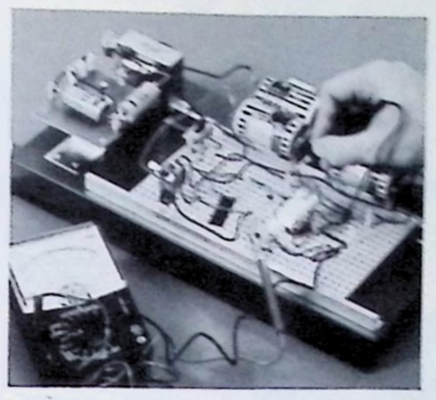

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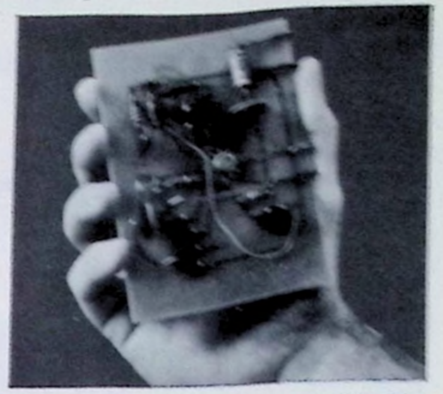

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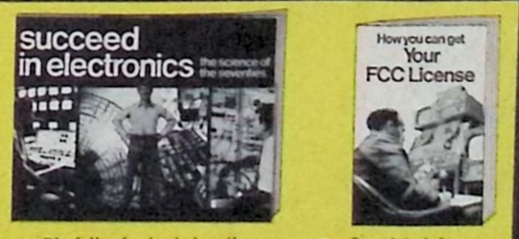
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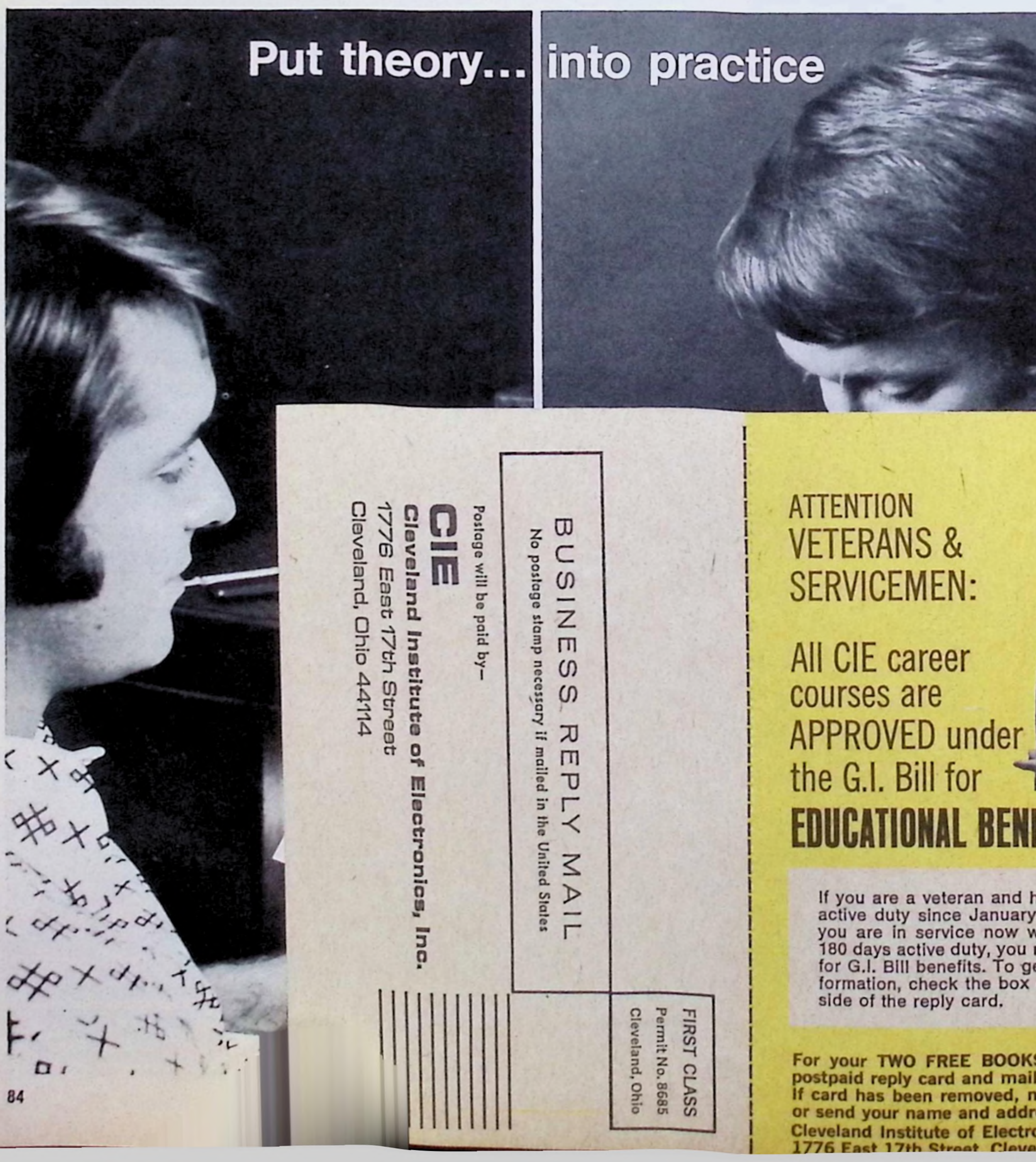

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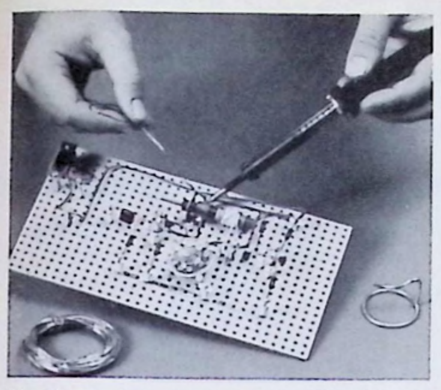
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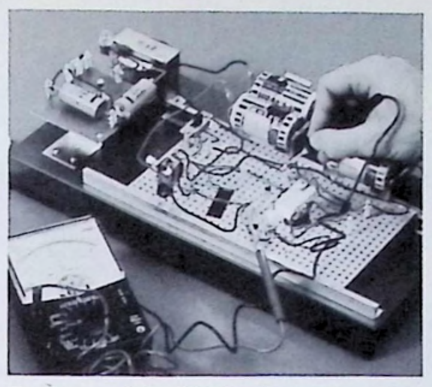
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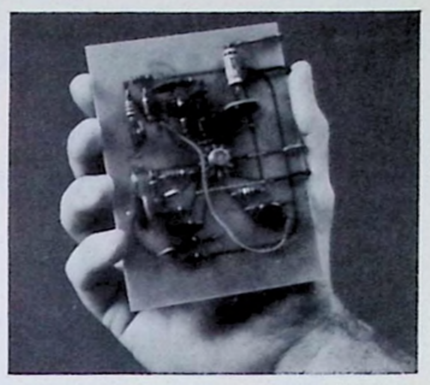
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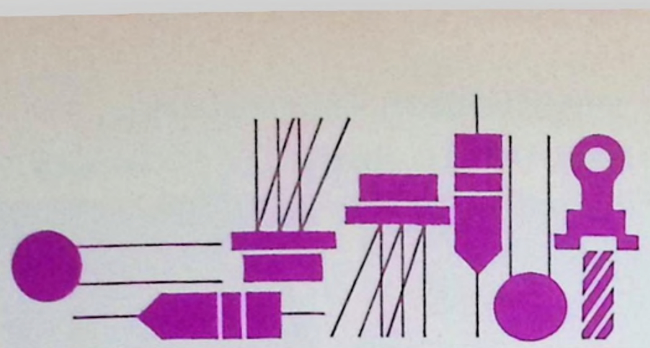

Solid State

By Lou Garner

LOOKING INTO THE CRYSTAL BALL

IF YOU'VE been a regular reader of this column, you know that I enjoy playing an annual guessing game with the electronics industry, predicting what new semiconductor products or technological advances will be introduced each year. For nearly two decades, my predictions have proven accurate better than 90% of the time. Because of this record, some have accused me of being an inspired prophet. Not so!

Actually, my annual predictions are based on an extrapolation of known developments in the industry. A "guesstimate" of where present trends are leading and what *could be* done with present technology. The method is similar to that used by science-fiction authors, but extended to the immediate, rather than the distant future.

Sometimes, my predictions have proven early by a year or so—simple examples of over-optimism and expectations that the industry would move faster in some areas than in others. Just as often, however, I've goofed in the opposite direction, predicting a new development which is announced *before* the colum appears in print.

Let's see how I fared with the predictions made in January, 1974. As you may recall, I predicted:

- *A substantial drop in the prices of digital electronic watches from the present hundreds of dollars*. Score one for the OM! Surprising just about everyone and catching some manufacturers with their inventories up, National Semiconductor Corporation's Novus Consumer Products Division (1177 Kern Avenue, Sunnyvale, CA 94086) introduced a line of six digital electronic watches in early fall with a list price on one model of only $125.00
- *Comparable reductions in the prices of digital electronic clocks*. Score another! At the same time that Novus announced its new low-priced electronic watches, it also announced a line of three digital electronic alarm clocks. The lowest priced model in the line lists at $34.95!
- *LED's at prices comparable to those of miniature incandescent lamps in small quantities*. Another home run (bull's-eye, or whatever)! Recent advertisements in these pages offered type MV50's at six for a dollar, MV5024 equivalents at eight for a dollar, MV5222 equivalent green LED's at five for a buck, and Mini-Red LED's similar to the MV50 at a whopping ten for a dollar.
- *The introduction of control-function IC's as stock items*. Chalk up another score! Space limitations prevent our listing all of the various control IC's now available through major distributors, but two moderately priced types which should be of interest to serious experimenters are the SGS-ATES L120 and L121 (SGS-ATES Semi-conductor Corp., 435 Newtonville Ave., Newtonville, MA 02160). Both devices are offered in 16-pin DIP's, both are priced at $6.00 each in unit quantities, and both are intended for control functions in industrial and consumer applications. The L120 is a Triac/SCR phase control and the L121 a Triac/SCR burst control.
- *The development of one or more new solid-state transducers*. WOW! We really hit the jackpot on this one. Several manufacturers introduced new solid-state transducers during 1974, with the National Semiconductor Corporation now offering so many types that it recently published the industry's first catalog/handbook on pressure and temperature transducers. Entitled *Transducers: Pressure and Temperature*, the 160-page volume is much more than a mere listing of device specifications and options. It covers general transduction theory as well as the theory of operation of IC transducers in particular, and includes a number of useful tables plus a lengthy glossary of transduction-related terms. The book's applications section discusses automotive, medical, and audio uses, cable fault location, and even musical instruments, such as an electronic clarinet that comes on like a Sousaphone. Copies of the book are available without charge on letterhead request to the Marketing Services Department, National Semiconductor Corporation, 2900 Semiconductor Drive, Santa Clara, CA 95051.
- *The introduction of low-cost (about $100) preprogrammed business calculators*. Another winner! Virtually all major calculator manufacturers have introduced inexpensive special purpose models. Casio, Inc. (Consumer Products Div., One World Trade Center, New York, N.Y. 10048), for example, offers one model, the Mini Root, which can supply square roots at the touch of a button and which provides automatic percentages for figuring markups and discounts, at a list price of only $54.95. The Cole-Parmer Instrument Co. (7425 North Oak Park Ave., Chicago, IL 60648) offers a metric conversion computer with full 5-function capability at a list price of only $84.50. And these are but a small sampling of the models introduced during 1974!
- *Digital electronic test instruments, such as VOM's and frequency meters, at prices comparable to those of instruments using moving-coil meter movements*. Is there any doubt?
- *Development of a new semiconductor manufacturing technique or a refinement in current techniques which will*

improve quality, increase yield rates, and lower costs. I admit to "hedging" slightly on this prediction, offering two alternatives. However, fortunately for the OM, both options were fulfilled during 1974. Nearly every major semiconductor manufacturer was able to improve production techniques to the point of boosting product quality while, at the same time, lowering prices. In addition, several firms introduced new techniques. RCA, for example, introduced a technological advance for the semiconductor industry by combining MOS and bipolar devices—PMOS, bipolar and COS/MOS—on a single chip. The first device offered based on the new technology is the CA3130 operational amplifier.

Supplied in an 8-lead TO-5 package, the CA3130 features a gate-protected p-channel MOSFET input stage with an extremely high input impedance of 1.5×10^{12} ohms and a complementary-symmetry (COS/MOS) output stage capable of swinging the output signal voltage to within a mere 10 mV of either supply voltage terminal. In addition, the device offers a wide 15-MHz bandwidth and has a sink and source current capability of 20 mA. Short-circuit protected, the CA3130 has a broad range of applications, including ground-referenced single-supply and fast sample-hold amplifiers, long duration timers and monostables, high-input-impedance comparators and wideband amplifiers, voltage-followers and regulators, peak detectors, single-supply full-wave precision rectifiers, and photo-diode sensor amplifiers.

- *The announcement of an unusual new solid-state device.* Another score! Not one, but several unusual new devices were introduced during 1974, many of which were discussed in these pages (including the CA3130). In making the original prediction, I suggested that one possibility was a special type of LED, speculating that it might have bilateral switch characteristics. In fact, a family of unusual new LED's was introduced by Litronix, Inc. (19000 Homestead Road, Vallco Park, Cupertino, CA 95014)—the RCL-200 series. These devices do not have switching characteristics as we speculated, but do incorporate a built-in bipolar current-regulator IC, permitting their use on dc supply voltages of from 4.5 to 12.5 volts without an external current limiting resistor.

Things to Come. Now for our predictions for 1975:

- *A price break-through on solid-state imaging devices*, possibly as a result of a new manufacturing technique. On a long term—several year—basis, I anticipate that video cameras will one day be as compact as home movie cameras and, perhaps, priced in a comparable range. [*Next month's issue will fulfill Lou Garner's prophecy–Ed.*]
- *The development of personal health monitors for patients subject to sudden attacks or seizures.* I envision a device no larger than a hearing aid which would alert the user in advance of a possible attack.
- *Digital electronic watches in the range of $50 to $60.* At the same time, I expect electronic watches in the hundred-dollar range to include a calendar feature, and, perhaps, even an integral alarm.
- *A digital MPG (miles-per-gallon) meter for automotive applications.* Such an instrument has been proposed but, as yet, is not in commerical production. I expect that it will be introduced first as a custom add-on accessory for retrofitting, but will be offered later as an optional accessory by one or more major manufacturers.
- *A low-cost electronic calculator designed specifically for the children's market.* As I visualize this product, it will

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- *An increasing variety of multipurpose consumer and office electronic products.* Typically, a combination alarm clock/calendar/calculator or a combination intercom/ dictating machine.
- *The development of low-cost portable electronic games.* These would be based on calculator technology, but would be self-contained and, unlike Magnavox's *Odyssey*, would not require a TV set.
- *The development of a high-output or high-intensity LED.* A standard LED can be pulsed at currents many times higher than its average continuous rating (typically, 1 A for a 50 mA LED). If designed specifically for pulse applications, it may be possible to use a LED as a light source for special purpose photography (such as infrared microphotography), or even as a warning light.
- *The development although not necessarily the commercial production, of solid-state energy control centers for homes and offices.* With the increasing energy crisis, overall heating/cooling efficiency becomes more and more important. There are many ways in which solid-state circuitry and devices could be used to increase the efficiency of building heating/cooling systems. Typically, controls to monitor temperature and humidity, adjusting energy flow to maintain the proper levels without waste, controls to adjust blower speed to an optimum level for heating or cooling, and warning systems to alert the user to system inefficiencies (such as clogged filters).

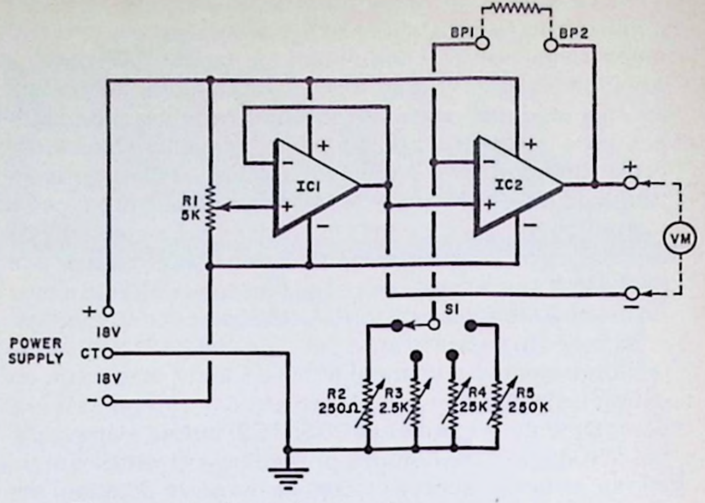
That does it! Next January, we'll check our score.

Readers Circuit. If you've used an ohmmeter to any extent, you've probably been frustrated on several occasions when trying to interpolate a value at the "squeezed" end of the nonlinear scale found on most such instruments. A little frustration apparently was too much for reader M. J. Guenther (1169 Prairie Rd., Port Coquitlam, B.C., Canada), for he put on his thinking cap and devised a *linear scale* ohmmeter, which he proceeded to build and has been using for some time. His circuit is illustrated above.

Guenther's design features a pair of op amps, *IC1* and *IC2*, a reference voltage source, established by *R1*, various ranges, selected by *S1*, and a voltmeter readout. Test terminals *BP1* and *BP2* are provided for checking unknown resistance (*Rx*) values.

The reference voltage obtained from *R1*, stabilized by voltage follower *IC1*, is applied to *IC2*'s non-inverting input. At the same time, *IC2*'s output is coupled back to its inverting input through a voltage divider consisting of the unknown resistor, *Rx*, and a preselected range resistor, *R2* thru *R5*. The net result is that *IC2*'s output voltage is equal to the reference voltage plus the reference voltage times the ratio of the unknown and range resistors. When a voltmeter is used to check the potential difference between *IC2*'s noninverting input and its output, the initial reference voltage is cancelled, giving a reading which is *directly proportional* to the unknown resistor's value, the basic requirement for a linear scale.

Guenther used type 741C op amps in his model, but suggests that a single type 747 dual op amp or other 741 types may serve as well. The pin connections will vary, of course, depending on whether a DIP, TO, or minidip type device is used. Range selector *S1* is a single-pole, four-position rotary switch, *R1* a conventional linear potentiometer, and *R2, R3, R4* and *R5* are small trimmer pots, although full-sized controls may be used. A dual 18-volt regulated (or zener stabilized) dc power supply is required for operation, while the readout instrument should be a high-impedance VTVM or FET VM.



Linear scale ohmmeter uses two intergrated circuits. When the circuit is properly balanced (via range switch and potentiometers), the meter reading is proportional to the unknown resistor.

In his letter, Guenther writes that he assembled his model as part of a home-built FET voltmeter, providing a pushbutton switch between *IC2*'s output and the voltmeter's input to prevent an off-scale reading when the test terminals are open.

Except for establishing the readout voltmeter range, the reference voltage adjustment, *R1*, is completely noncritical, according to Guenther. He suggests calibrating the instrument by using mid-scale value precision (1% or better) resistors as test units to adjust each range potentiometer. In his model, Guenther used test resistors (as *Rx*) of 50, 500, 5,000, and 50,000 ohms, adjusting *R2, R3, R4,* and *R5,* respectively, to provide ranges of 0-100, 0-1,000, 0-10,000 and 0-100,000 ohms.

Device/Product News. If my discussion of field-effect transistors and their applications in last November's column stimulated your interest in these versatile devices, you may want to investigate recent offerings by Siliconix, Inc. (2201 Laurelwood Road, Santa Clara, CA 95054): these include a pair of vhf/uhf FET's and a new series of monolithic matched dual FET's.

The new vhf/uhf devices are basically the popular U310 n-channel high-frequency JFET supplied in epoxy TO-92 or ceramic OD-81 package configurations. These devices may be used as amplifiers, oscillators or mixers.

Siliconix's new dual JFET's, designated the E410 family, are epoxy-packaged n-channel devices intended for low- and medium-frequency small-signal differential amplifiers requiring matched gate-source voltage, high common-mode rejection ratio and low output conductance. The three units, types E410, E411 and E412, have a maximum G-G voltage of ±40 V, a maximum G-D or G-S rating of −40 V, and a maximum gate current of 50 mA, with a total package dissipation of 350 mW. Their common-mode rejection ratio is at least 70 dB.

In addition to its new FET's, Siliconix also has announced a new line of low-capacitance, high-impedance diodes intended for circuits requiring clipping, clamping, or over-voltage protection. Identified as the PAD family (pico-ampere diode), the new devices feature minute leakage currents ranging from 1 pA (PAD-1) to 100 pA (PAD-100) and extremely low interelectrode capacitances of 0.8 to 2.0 pF. The typical forward voltage drop for all units is 0.8 volts, the maximum forward current is 50 mA, and the total device dissipation 300 mW.

A new series of low-voltage varistors has been introduced by GE's Semiconductor Products Department (Bldg. 7, MD #49, Electronics Park, Syracuse, NY 13201). Performing somewhat like back-to-back zener diodes, these devices are ideal for protecting costly power transistors against transient voltage peaks when used in high-current inductive circuits, such as power supplies, inverters, converters, alarms, solenoid drivers, and audio amplifiers. Physically similar to disc ceramic capacitors, the new devices, designated the "ZA" series, are offered with ratings from 26 Volts dc, 20 Volts rms to 81 Volts dc, 60 Volts rms.

Motorola's Semiconductor Products Division (P.O. Box 20924, Phoenix, AZ 85036) has announced five new ruggedized r-f power transistors which should be of interest to hams and other communications buffs. Designed for 40-to-110-MHz mid-band international mobile radio applications, the new devices, types MRF 230 through MRF 234, are drivers and final amplifiers rated at 1.5, 3.5, 7.5, 15 and 25 watts output, respectively. Individual device gains are kept within 10 dB, while operation at VSWR's of up to 30:1, at any phase angle, can be tolerated. Unit prices range from $2.30 for the MRF 230 to $16.90 for the MRF 234.

Back East, RCA's Solid State Division (Box 3200, Somerville, NJ 08876) has introduced three new families of medium-power transistors and eight new general-purpose IC op amps.

The RCA29/SDH, RCA31/SDH and RCA41/SDH series are single-diffused hometaxial-base versions of the RCA29, RCA31, and RCA41 epitaxial base series, respectively, and are intended for a wide variety of switching and amplifier applications, such as series and shunt regulators and drivers and output stages of high-fidelity amplifiers. All the devices are supplied in JEDEC TO-22AB packages.

The RCA29/SDH series has typical turn-on and turn-off times of 2.3 µs and 6 µs, respectively, with a minimum beta of 15, measured at 1 ampere. V_{CEO} ratings range from 40 to 100 volts, depending on type. Featuring similar turn-on and turn-off times, but a minimum beta of 10, measured at 3 amperes, the RCA31/SDH series is offered with comparable V_{CEO} ratings. Finally, the RCA41/SDH series has typical turn-on and turn-off times of 3.2 µs and 3.7 µs, a minimum beta of 15 at 3 amperes, and voltage ratings of 40, 60, and 80 volts, depending on type.

Designated types CA107T, CA207T, CA307T, CA101T, CA101AT, CA201T, CA201AT and CA301AT, RCA's new IC op amps are direct replacements for standard industry types such as the 107, 207, 307, 101, 101A, 201, 201A and 301A in packages with similar terminal arrangements. These are dual-supply, high-input-impedance devices suitable for use in sample and hold, comparator, low-frequency waveform generator, long-interval timer, summing amplifier, and multivibrator applications. All eight types are furnished in 8-lead TO-5 style cases.

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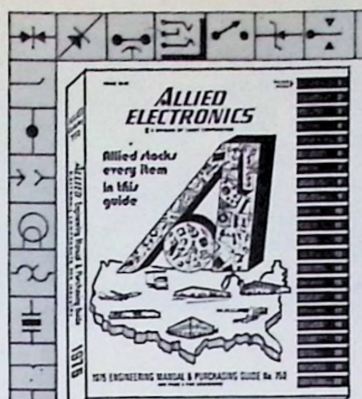
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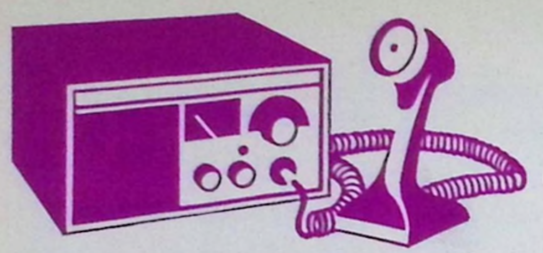

CB Scene

By Len Buckwalter, K10DH

CB'S RED BARON

THERE we were at 1,000 feet, our wings at a crazy angle, the ground rushing up, when all of a sudden . . ..

That's how it felt when I recently took a ride with one of the world's rarest birds—a flying CB reporter. His name is Morgan Kaolian, and he pilots a flivver of a plane on weekends for a local radio station located near the big boating areas of New York and Connecticut. Morgan's become something of a legend in these parts because he buzzes through the air for 18 hours every weekend to deliver half-hourly broadcasts of weather, fishing, sea conditions and road traffic, plus a few surprises. When I caught wind that Morgan depends heavily on CB, I decided to investigate, and maybe wangle a free hop in his flying machine.

Most people think flying reporters re in helicopters. Not so in this case. he plane is aviation's Model A; a vo-place Cessna-150 that cruises about 90 mph, squeezes 15 miles from a gallon of gas and emits about as many decibels as an overweight wasp. A helicopter, on the other hand, noisily chomps the air, costs upwards of $80 an hour to operate and is usually an expensive big-city bird. Morgan's mini-machine slashes the cost, and CB takes a share of the credit in the electronic department.

When I first spoke to Morgan on the phone he asked me how much I weighed. "One hundred ninety," I replied, wondering if the beefy figure would ground me. The reason he asked is that the plane is loaded to the gunnels with radio equipment and sprouts antennas like a flying porcupine. A two-way vhf link on 161.7 MHz carries his voice to the ground for retransmission over WICC, an AM station on 600 kHz. In the instrument panel there's an AM receiver so he can monitor the radio announcer for cues (but a closer look reveals it to be a Volkswagen car radio!). Back in the minuscule baggage compartment is a typewriter-size vhf radio and the rest of the cabin is criss-crossed with the microphone cords and dangling headphones. With all this electronics aboard, no wonder Morgan was concerned about poundage.

The CB installation turned out to be something less than you'd find aboard a Boeing and more like a typical hobbyist's shack—a disarray that's understood only by the person who grew it. Since the Cessna's Lilliputian cabin was already bursting with instruments, the CB set was stuffed into a map pocket behind the backrest of a seat. The tiny knobs of the CB rig peeked out of the pouch like a baby kangaroo. The antenna installation, though, was an aircraft-type spike loaded for CB channel 13 and permanently mounted on the fuselage. Power for the rig was picked up through the aircraft's 12-volt dc buss in automobile fashion.

As we taxied out for take-off, the pilot clamped on headphones and handed me a pair. The "cans" were a comfortable set—until Morgan turned up the audio with a wicked smile. *All* the plane's radios feed into the phones simultaneously. Trying to catch the voices of the control tower, ground controller, CB receiver, vhf receiver and AM monitor would be easy if I were a 5-channel tape recorder, but Morgan has been doing it for 8 years and easily sorts out the audio bedlam. As the 100 horses of the Cessna engine struggled to lift us into the air, I regretted the box of Oreos I had eaten the night before.

"Hey, here comes Eddie Rickenbacker!" It was the first CB voice of the flight. Morgan wheeled the plane around and headed toward a row of boats moored below, then lowered the plane's right wingtip to point out a single cabin cruiser. "That's the city police," he explained. "They monitor channel 13." Morgan exchanged pleasantries with the floating police and I was suddenly impressed at the good fortune of CB-equipped boatmen in the area. Maybe the U.S. Coast Guard won't hear CB distress calls, but there's a good chance they'll be intercepted by this channel 13 search-and-rescue team.

On an average weekend Morgan saves about two boats in distress. It's most efficient if the boat has a CB rig because its captain simply calls on channel 13 and may speak directly to the aerial angel-of-mercy himself. The range of a CB "air mobile" is very great with its lofty antenna, and talking distances of 50 miles are average (or double that when altitudes rise to three or four thousand feet). If a boat has no CB, Morgan may flit to a nearby boat and direct it to the crippled craft. When radio communications won't work he relies on more sensational feats. He'll drop written instructions in a sandwich bag or fly down low and *shout* directions. "Won't the noise drown out your voice?" I asked, with some doubt. "No, I kill the engine gliding down."

Morgan's uncanny skill at skimming the waves reaps another bonanza for CB'ers in the area. It's fish-spotting by air. To demonstrate, he lowered the Cessna's nose and

Flying reporter Morgan Kaolian uses CB for much of his aerial communications.

asked me, "Do you have any aversion to low flying?" As the sea rapidly filled the windshield, I replied, "N-n-n-no." Blue fish, he explained, are visible as they break the surface, while bunkers expose themselves by thrashing about. Schools of fish below the surface look like dark holes. If he spots any giveaway signs, he'll report them to CB'ers below who call in. He's even been known to assist unlucky anglers with a helpful "Follow me."

The plane was now over land and flying parallel to a busy interstate thruway. Although he gives traffic reports on his regular AM broadcasts, I wanted to see the interaction between a CB-equipped plane and an automobile in motion. We raised a mobile who described himself as a yellow Chevy pickup truck with a load of lumber travelling on Route 1. Seconds later, over a tangle of roads choked with homeward-bound vehicles, Morgan started circling. "Do you see it?", he asked me. All I could see was traffic—but it seemed he spotted everything below about an hour before I did.

CB set is carried in pocket behind seat.

"I see you!" peek-a-booed the yellow Chevy. Finally, looking like a Tonka Toy, the teeny mobile with its matchstick load of lumber caught my eye. Morgan nudged me and, with a gleam in his eagle eye, said; "I estimate he's going 30 miles per hour." He squeezed the CB mike and fired the question.

"I'm going 30 miles per hour" answered the yellow pickup.

Morgan's ability to interface with road traffic has even rescued lost souls on the ground. One time on CB he heard; "Does anyone know where the church is on Brooklawn Road? Some fellow is on his way to a wedding and he's lost."

Antenna, on plane's fuselage, is cut for channel 13.

"Where are you?" asked Morgan.

When the driver gave his location, Morgan swooped down like a hawk on a hapless hare.

"Is that you in the red Corvette?"

"That's me."

"Well just keep going, the church is straight ahead." Chalk up another save for CB. Morgan even saw the man *going* to the wedding!

The airport runway lights were already glowing as our Cessna touched down at the end of the day. Moments before we had listened on channel 10, with its CB-equipped truckers talking of roads and loads, or inviting each other to coffee at the next stop. I was surprised by one trucker who asked another driver if he had a "reefer." Morgan quickly explained that he meant a "refrigerated" truck. (He seems to know a little about everything, which may explain why he's also called the "Flying Mouth.") A twist of the selector to CB channel 9 brought remarkable silence, considering that it's often misused and our receiving range in the air was so great.

Morgan and his aerial antics via CB may serve as an inspiration for other pilots and communities. He's spreading tremendous goodwill for CB and proving the medium's worth in public service. The only precaution is that this sort of activity should be done only by experienced airmen. Morgan has a good luck charm (an "evil eye") pinned to the roof of his cabin, but his 8 years of accident-free reporting is also helped by 4,000 hours in the air and his experience as a military flier. Thanks to him we can say CB is on land, at sea—and in the air, too! ◆

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Amateur Radio

By Herbert S. Brier, W9EGQ

RECEPTION AND THE ATMOSPHERE

HAVE you ever turned your receiver on and tuned across a band only to find that it was completely dead? This has probably happened to every amateur at one time or another. The first reaction is, "Oh, no! Something's gone wrong with my receiver!" In most cases, though, the fault lies not in the gear but in the propagation conditions affecting the band or bands. Why are bands so fickle and unpredictable?

The reasons for such occurrences lay in the interaction of the atmosphere, the sun, and radio waves. Let's consider the nature of these relationships, and how they affect radio communications.

Our atmosphere consists of four distinct regions—the troposphere, the stratosphere, the ionosphere, and the exosphere. Two of these strata directly contribute to the propagation of radio waves. The troposphere, which extends from 0 to 7 miles, (0 to 11.2 km) can act as a waveguide for vhf and uhf signals, but has little effect on hf transmissions, as does the stratosphere, which extends from 7 to 25 miles (11.2 to 40 km). From 25 to approximately 250 miles (40 to 400 km) we find the ionosphere. In this region, rarified gas molecules and atoms can lose some of their electrons when excited by solar radiation. They disassociate into ions and free electrons, having positive and negative charges, respectively. Since the ions are thousands of times more massive than the electrons, they tend to be much less mobile. The electrons, however, tend to cluster in layers—the D layer, at 37-57 miles (60-92 km), the E layer, at 62-71 miles (110-115 km), the F_1 layer, at 99 miles (160 km), and the F_2 layer, found between 130 and 261 miles (210-420 km), depending on the season, the degree of ionization, and other variables. (See diagram shown at right.)

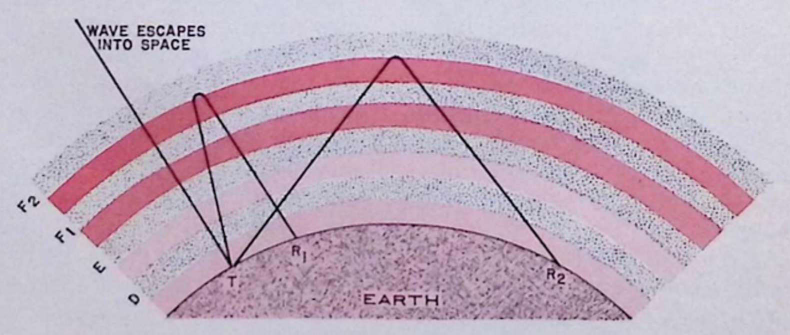
At night, the picture changes slightly. In the absence of the ionizing solar energy, the D layer disappears after sunset. The E layer, which like the D reaches its maximum ionization level at noon, is at a minimum around midnight, when the free electrons recombine with the ions in the absence of solar radiation. The F_1 and F_2 layers merge into a single F layer after sunset, at a distance between those of the individual layers. Since the distribution of atoms at this height is so thin, the recombination process is much slower than in the D or E layers. Maximum ionization occurs at noon, and tapers off very gradually after that, remaining at a fairly high level through the night. A minimum is reached just before sunrise, at which point the ionization increases rapidly. Within an hour or two, it is back to daytime levels.

The final stratum, called the exosphere, is made up mostly of protons (hydrogen nuclei), and other charged particles that have been carried from the sun as part of the "solar wind." This region acts as a primary shield against the buffets of solar disturbances, but its effect on radio propagation is not great.

When the transmitter, at T, causes the antenna to radiate, the waves will leave the antenna at various angles. The one that travels straight up enters through the ionization layers and escapes into space, never to return. Other waves leave the antenna at various angles from the tangent. Let us look at two of the signals. The wave with the higher departure angle, also called the wave angle or angle of radiation, first enters the D layer, where it is attenuated to a degree inversely proportional to its frequency. This is due to the fact that each time the signal collides with an electron or ion, part of its energy is lost in exciting the particle. Since the D layer is so dense, much attenuation takes place here. D-layer absorption is so great at low frequencies (5 MHz and below) that most of the signal doesn't make it through this layer. This is why 160 and 80 meters are usually "dead" during the daytime, but can open up at night.

If the signal is strong enough, and/or of high enough frequency, it will pass through the D layer with a good degree of strength. It will then travel up to the E layer. If the E ionization is high enough, and the wave angle is below a critical value, it will be reflected back toward the earth at about the same angle as the incident one. The wave will then pass through the D layer and reach the earth at a good distance from the transmitter.

If the E layer is not highly ionized, the wave will pass through it and reach one of the F layers, although its direction may be modified by partial bending. When the wave reaches the F layer, it will be reflected back toward earth if the wave angle is less than the critical value, and the frequency is below the "maximum usable frequency," or MUF. If the angle and/or frequency is greater than these values, the wave will pass into space. If the wave is sent back, it will pass through the other layers, and perhaps be sent back up by the E layer, and reflected down by the F layer at another point. The greatest range available from a "single hop"



Signals may be reflected by a layer of the ionosphere or escape into space. Range is determined by layer height and wave angle.

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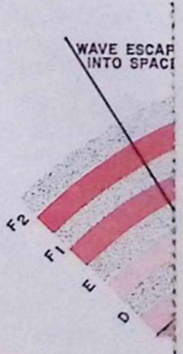

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Rick, WB9EWQ, uses a Heathkit Electronic Keyer with HW-16 and HW-101 transceivers.

off the F layer is about 2500 miles (4000 km), and about 1250 miles (2000 km) from E-layer reflection.

The range available from this ionospheric reflection (also called sky-wave propagation) depends on the height of the layer(s), the degree of ionization, the angle of radiation and transmitter output power. In the diagram are two sky waves received at R_1 and R_2. The angle of radiation of the wave reaching R_1 is much greater than that appearing at R_2, and the range, as you can see, is much less. While it is possible to cover the distance to R_2 by more than one hop with a higher angle of radiation, the multi-hop signal will be weaker. Each time the wave hops, it loses about 6 dB or one "S" unit of strength. A two-hop signal would thus be 12 dB weaker than one which arrives after a single jump.

Amateurs who wish to work DX are interested in having antennas which radiate the larger portion of applied power at low angles. It has been found that the median wave angles for distant signals arriving at the receiver antenna on the hf bands are—28 MHz, 9 degrees; 21 MHz, 12-14 degrees; 14 MHz, 15 degrees; 7 MHz, 30 degrees; and 3.5 MHz, under 45 degrees. For horizontal dipoles, the following heights will give the desired radiation patterns: 28, 21 and 14 MHz—70 feet; 7 MHz—70 to 90 feet; and 3.5 MHz—90 to 140 feet. These heights are not absolute, since there are times when a lower or higher height would be more desirable.

Solar Influences. The degree of ionization is dependent on the activities of the sun, and the proximity of the earth to the sun. Sunspots are directly related to the levels of solar radiation. When there are many sunspots, the ionization level go up. There is an eleven year sunspot cycle. The last maximum occurred about 5 years ago, and we are now well into the waning period.

As we are well into the waning year of the current sunspot cycle, the 14-, 21-, and 28-MHz bands will normally be dead after dark for the next few months—except for unpredictable "short-skip" propagation conditions that can occur at any time on these bands. In addition, unless you have better-than-average 3.5- and 7-MHz antennas, signals on these frequencies become weak and hard to work as the evening progresses. If your antenna system is less than top-notch, you may hear operators with good 3.5- and 7-MHz antennas having no trouble working stations you can barely copy. Unless you can put up better low-frequency antennas, the easiest way to cope with the situation is to do more daytime operating. Although the 28-MHz band will often be dead, even in the daytime, the 3.5-to-21-MHz bands are and should continue to be useful for distances from 100 to several thousand miles from morning to night for the next few years.

You will also feel the effects of seasonal influences. Since the earth is closer to the sun in winter, F_2 ionization is more intense and higher MUF's are the rule. E-layer MUF's are generally lower in winter than in summer. The F_1 layer often disappears entirely during the winter, while it demonstrates MUF's of about 5 MHz in the summer. Night-time MUF's during the winter of the minima may drop to less than 4 MHz, as you will notice over the next few months.

If hf conditions deteriorate to the point where few contacts are possible, and you are looking for more QSO's, investigate the amateur vhf scene. If your attention has been focussed on the frequencies below 30 MHz, you cannot imagine the population explosion that has taken place on the amateur frequencies above 50 MHz—especially on the 144-148-MHz band. This is due to the wide availability of low-power vhf FM transceivers about the size of a big box of candy. When these units are used in conjunction with the vhf repeaters that have sprung up all over the country, ultra-reliable local communications have become an actuality for any operator within 25 or 30 miles of a repeater. Antennas need not be elaborate.

For further information on modern vhf operation, try the *VHF Handbook For Radio Amateurs*, by Herbert S. Brier, W9EGQ, and William I. Orr, W6SAI, Radio Publications, Inc., Wilton, Conn., or *FM and Repeaters*, ARRL, Newington, Conn. These books are available from most amateur equipment distributors.

In addition, do not hesitate to put out a couple of CQ's on an apparently dead band. One of the never-ending fascinations of amateur radio is its unpredictability. Also, the bands are often open to remote localities; and no one ever finds out because of the lack of activity at the right times and places. Evidence of this is furnished in practically every amateur contest.

News and Views. Send news, comments and pictures for possible publication in this column to: Amateur Radio, Herbert S. Brier, c/o POPULAR ELECTRONICS, One Park Ave., New York, NY 10016. ◆

SELECTED CONTESTS

ARRL VHF SS Contest; 2:00 P.M. local time, Saturday, Jan 7, to midnight, local time, Sunday, Jan. 8, 1975. Exchang number of contest contact; "A" if yo power input is less than 50 watts, "B" it is 50 watts or more; your call lette "check" last two digits of year licensed, ARRL section.

International DX Contest (ARRL); 0001 GMT, Feb. 4 to 2359 GMT, Feb. 5, and same time March 4 and 5; phone. Same times, Feb. 17 and 18, and March 17 and 18; CW. Send signal report and name of your state or province to each DX station worked. Receive signal report and power input. Score: add the number of different stations worked on each band and multiply by number of different countries worked.

Novice Roundup (ARRL); 0001 GMT, Feb. 4, to 2359 GMT, Feb. 12; operate a total of 30 hours. Novices can work anybody. Others work only novices. Exchange call letters, signal reports, and name of ARRL section. Novice scoring: add the number of different stations worked to the highest code speed recorded on your ARRL code-proficiency certificate. Multiply by the sum of sections and countries (other than ARRL sections) worked.

Complete literature and last-minute rule changes for each of these contests are available from ARRL, Newington, CT 06111, upon request accompanied by an addressed return envelope. Affix 8 cents postage for 3rd class return, 30 cents for first class. Send scores to same address.

Test Equipment Scene

By Leslie Solomon

REJUVENATING ELDERLY EQUIPMENT

ALTHOUGH most of us would like to purchase the best test gear that we can afford, we often have to compromise when it comes to cost. This means that many workbenches may have test gear whose specifications are not much better than the equipment being tested. In which case, we may be violating one of the basic rules of good engineering (and servicing): test gear must be at least one order of magnitude more accurate than the device being tested.

In many instances, a few more years can be squeezed out of the old gear simply by "swiping" partial or whole circuits out of magazines like POPULAR ELECTRONICS. Although most of us never build even a small percentage of the various circuits we see, we should take a close look at them with an eye for ideas to improve our present test equipment. Over the past few years, we have found many circuits that could be used to upgrade our test gear. The best part of this approach is the very low cost involved. (The few hours of bench time required to assemble the circuits are actually enjoyable when you're accomplishing something.)

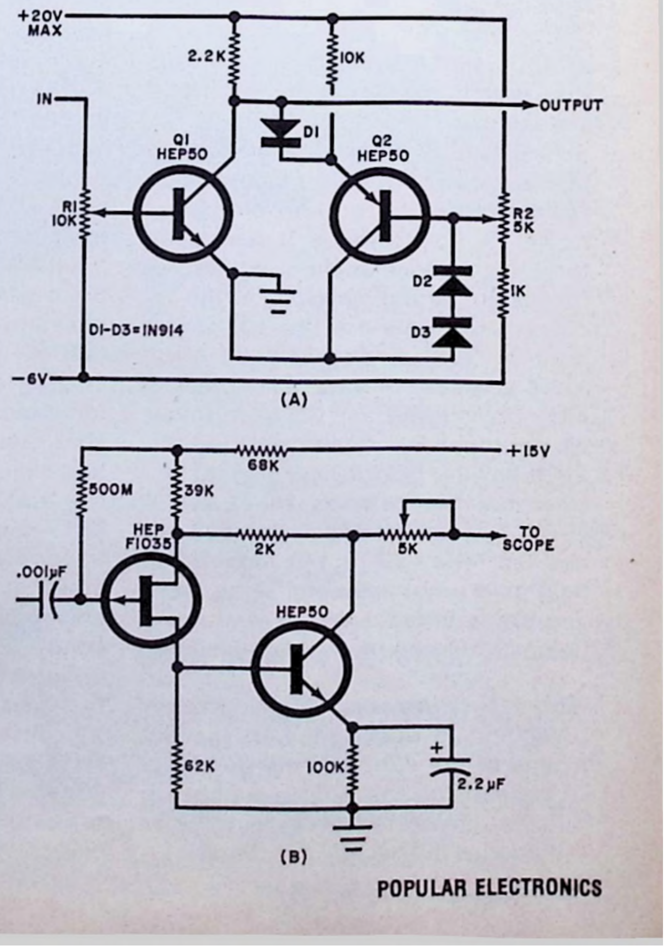
Consider an elderly square-wave generator. This old timer might do very well at the lower audio frequencies; but as the frequency goes up, the output square wave probably resembles a badly warped triangle wave, at best. You can try to improve the high-frequency response by using the output to drive some digital logic, such as a flip-flop. This would work, but you will need a 5-volt power supply, and the frequency will be halved. A Schmitt trigger circuit would probably work fine. However, you might want to try the circuit shown at (A). It converts the battered old waveform into an impressive square wave with fast rise and fall times, reaching way out in frequency. The amplitude is also constant over the entire span. We built this circuit right into the old generator, taking the required power from the internal supply. Any silicon switching transistors and diodes can be used.

The input potentiometer *(R1)* is adjusted for the best output waveform. Once set, this control requires no further calibration. Potentiometer *R2* is used to set the output amplitude. Diode *D1* protects the *Q2* emitter-base junction while diodes *D2* and *D3* prevent the clamp voltage from reverse biasing. *Q1*. The input is driven from the maximum output of the old square-wave generator.

Another piece of gear that needed help was an old oscilloscope. Although it had the usual I-megohm impedance, we found that it did load some of the newer circuits, especially where CMOS or bootstrapping were used. To reduce this loading effect, we began using a 10:1 divider to increase the input impedance. But this, naturally, reduced the signal level available to the scope. We then had to crank the vertical gain way up, and sync sometimes became unstable. The circuit shown at (B) uses a form of bootstrapping to produce an input impedance somewhere around 1000 megohms. The circuit has unity gain, while the upper frequency equalization is determined by the setting of the 5000-ohm potentiometer.

The rise time is quite fast, and is estimated at about half a microsecond. The circuit was built on a narrow pc board and mounted within an old metal cigar tube container, as a probe. We have had no circuit loading problems.

Although we have shown only a couple of relatively simple ideas, there are many more. Where do these ideas come from? When we receive our quota of construction and ham magazines, besides reading those articles that interest us, we take a look at all the circuits, searching for ideas that may sometime be useful. Once we see something that could be of use, we clip it out and file it in a set of folders that are categorized by applications—audio, test gear, power supplies, etc. If you don't like the idea of cutting up



Circuit (A) can be used to improve the waveform on a square-wave generator; while (B) can be added to an oscilloscope to reduce input impedance.

magazines, then start a card file, recording the title of the article, the magazine, the month and year, the page number, and the idea you have in mind. At some later date when you are looking for help, all you do is look in your files under the proper heading, find the article, break out the soldering iron, and update.

Circuit Loading. Several times in the past, we have mentioned that measuring voltage with a VOM is not the same as measuring it with a VTVM, VTM, DMM or any other high-input-resistance instrument.

Let us take the case of a circuit having a 10-volt power supply and a series output resistance of 50,000 ohms. If you are using a VOM with a 20,000-ohm dc resistance, the current flow through the circuit will be $10/(7 \times 10^4)$, with the 70,000 ohms being the sum of the 50,000-ohm series resistance and the 20,000-ohm VOM resistance. The current is then 1.43×10^{-4} amperes. The voltage drop available to the VOM $(1.43 \times 10^{-1})(2 \times 10^1)$ or 2.86 volts. The error is then (10-2.86)/10 times 100 or 71.4%.

If you plug the VTVM 10-megohm input resistance into the above equations in place of the 20,000 ohms of the VOM, you will find that the current now becomes 9.95×10^{-7} amperes. The voltage drop across the VTVM is now 9.95 volts, and the error is only 0.5%.

You can use the dc resistance of your own VOM and VTVM (or other high input resistance voltage instrument) to determine for yourself just how inaccurate those voltage measurements have been in the past. You will see that the higher the input resistance of the voltage measuring device, the greater the accuracy. ◆

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by Hank Bennett

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Perhaps the most valuable aid in the book is a thorough list of foreign stations, by country, which includes exact frequencies and times of transmission. There is also included a discussion of the DX possibilities for the various frequency bands given the time of day, the season, and the point in the 11-year sunspot cycle. If you are entertaining notions of involving yourself in shortwave listening, there are few sources which can whet your appetite as well as this.

Published by Tab Books, Blue Ridge Summit, Pa. 17214. 281 pages. $.9.95 hardcover; $6.95 paperback.

TRANSISTOR FUNDAMENTALS AND SERVICING

by B. Larson

The text covers the fundamentals of electronic devices to instruct readers in servicing circuits and systems in which they are found. Among the topics discussed are diodes, power supplies, bipolar transistors, bias circuits, ac amplifiers, FET's, IC's, oscillators, vacuum tubes, and the oscilloscope. Troubleshooting methods for each of these components and networks are given. Packaging and conventions for the various active elements are given. The emphasis in this book is on servicing, rather than design, with circuits reduced to the bare essentials and presented in a highly simplified manner. Short-answer, multiple-choice questions and problems conclude each chapter.

Published by Prentice-Hall, Inc., Englewood Cliffs, NJ 07632. 462 pages. $14.95, hard cover.

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by Deem, Muchow, and Zeppa

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Published by Howard W. Sams & Co., 4300 W 62nd Street, Indianpolis, Ind. 46206. 368 pages. $9.95, paperback.

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by Herb Brier and William Orr

This guide to the "line-of-sight" frequencies begins with a short history of vhf exploration and experimentation. The most popular vhf bands include more than 13 MHz of spectrum space, more than four times the capacity of the hf bands. Since many amateurs are moving higher and higher to avoid congestion and QRM, this book will be a valuable reference work for newcomers to the high bands. Vhf propagation, caused by ionospheric reflection, moonbounce, tropospheric, auroral, and meteor effects is explained. The Oscar series of satellites is examined, and special emphasis is given to earth-station configurations. The very popular FM scene, including repeaters, mobile links, and tone-encoding controls is discussed. Design theory and construction practices for antennas, solid-state amplifiers and receiving circuits are explained and illustrated.

Published by Radio Publications, Box 149, Wilton, CT 06897. 336 pages. $5.95, soft cover.

ELECTRONIC TEST EQUIPMENT —AND HOW TO USE IT

by J. Risse

A guide to the practical uses and proper operation of test equipment, this book gives principles, functions, and applications for tube and semiconductor testers, signal generators, capacitance and inductance bridges, and oscilloscopes. A list of key questions is included at the end of each chapter to allow the reader to check himself on new material as it is presented.

Published by Tab Books, Blue Ridge Summit, PA 17214. 204 pages. $7.95, hard cover; $4.95, paperback.

SOLID STATE IGNITION SYSTEMS

by R. Graf and G. Whalen

Fundamentals of the various electronic ignition systems that are becoming more and more popular in today's cars are discussed, and the conventional Kettering system is examined. Inductive-discharge and capacitive-discharge using solid-state components are covered by describing representative types offered by auto manufacturers and supply houses. Trigger methods, from breaker-point (with CDI) to magnetic "pointless" systems available as an option on most new American cars are included.

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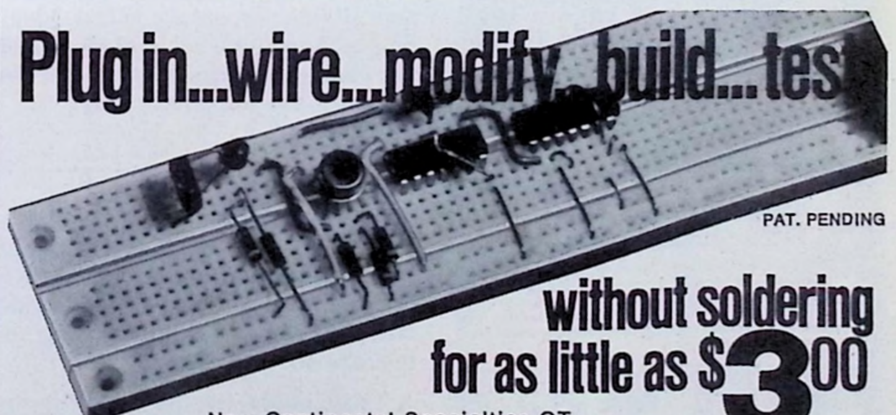

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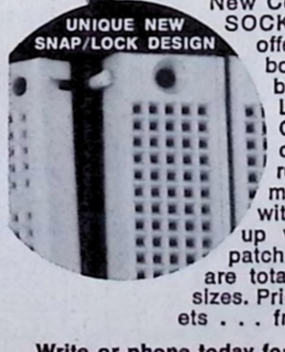

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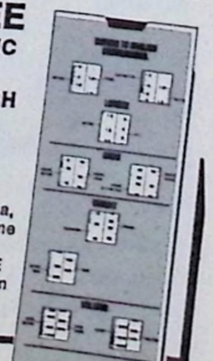

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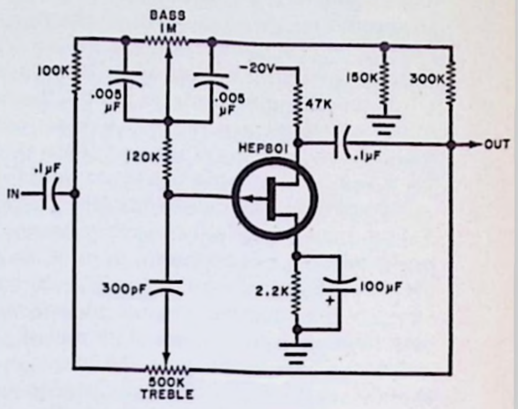
Q. *I purchased a low-cost, general-utility, solid-state preamplifier and power amplifier to supply background music on my open patio. Now I find that I need some form of tone control to get a better sound. Is there a simple way to do this?*

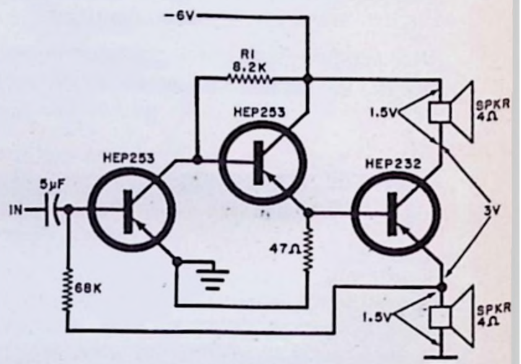
A. The tone control shown here can be inserted between the preamp and the power amplifier. You will have to get the power supply from the amplifier.


BASS 1M
100K
.005 µF
.005 µF
-20V
47K
150K
300K
HEP801
.1µF
OUT
120K
.1µF
IN
300pF
2.2K
100µF
500K TREBLE

ONE-TRANSISTOR PUSH-PULL OUTPUT

Q. *Is it possible to arrange a one-transistor push-pull output to drive two speakers–one in the emitter circuit and one in the collector?*

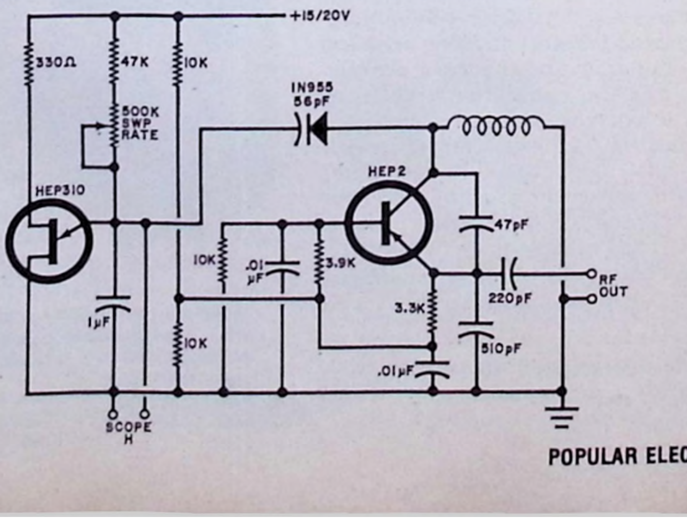
A. This circuit can be used to drive a pair of 4-ohm speakers with a 1-watt output. Adjust the value of *R1* to give the voltage drops shown across the speakers and the output stage.


-6V
R1 8.2K
HEP253
1.5V
SPKR 4Ω
HEP253
HEP232
5µF
IN
3V
47Ω
68K
1.5V
SPKR 4Ω

A ONE-TIME SWEEP GENERATOR

Q. *I need some kind of r-f sweep generator to align the i-f of a receiver I built. I have no need for a commercial unit–just something simple for this one-shot alignment.*

A. You could try the basic circuit shown here. The UJT output goes to the horizontal (external) input of the scope; and you can set the desired sweep rate with the potentiometers. The varactor can be any one in the range of about 50 pF. Use a Miller 9003 coil with a range of 380 to 1000 kHz for a 455-kHz i-f or a Miller 4505 (10 to 14 MHz) for a 10.7-MHz i-f. Other coils can be used for other ranges.


+15/20V
330Ω
47K
10K
1N955 56pF
500K SWP RATE
HEP2
HEP310
47pF
10K
.01 µF
3.9K
RF OUT
220pF
3.3K
1µF
10K
510pF
.01µF
SCOPE H

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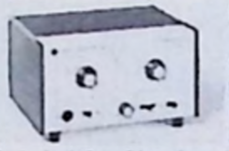

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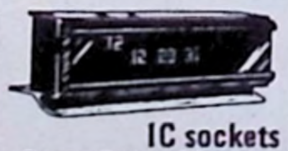

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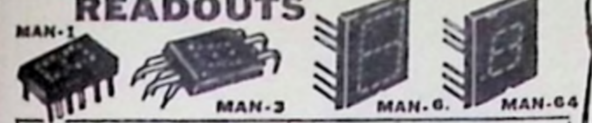

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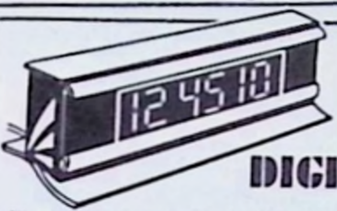

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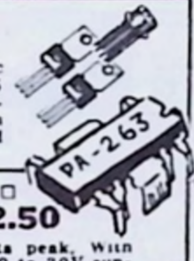

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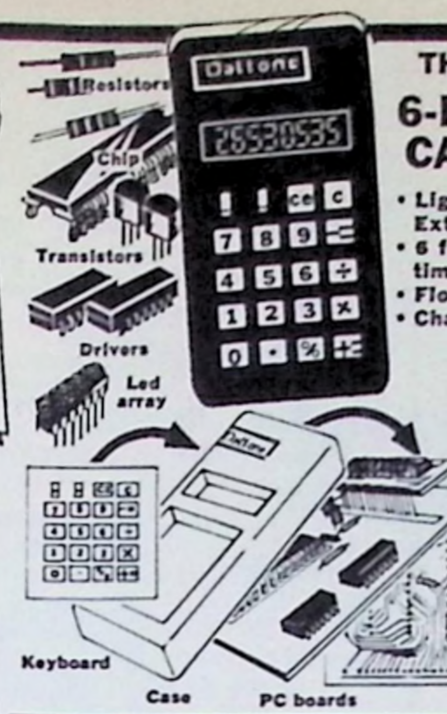

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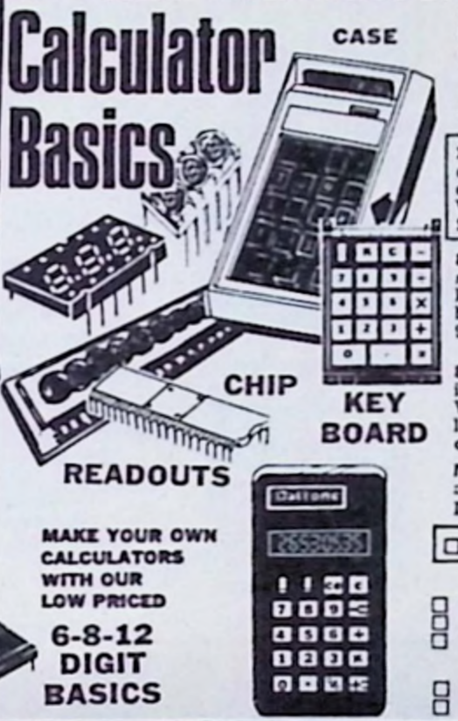

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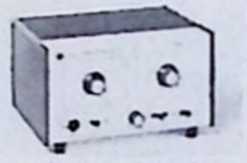

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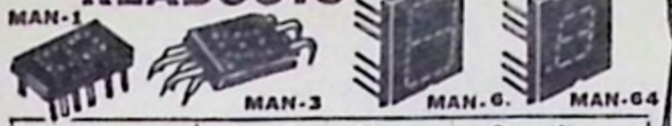

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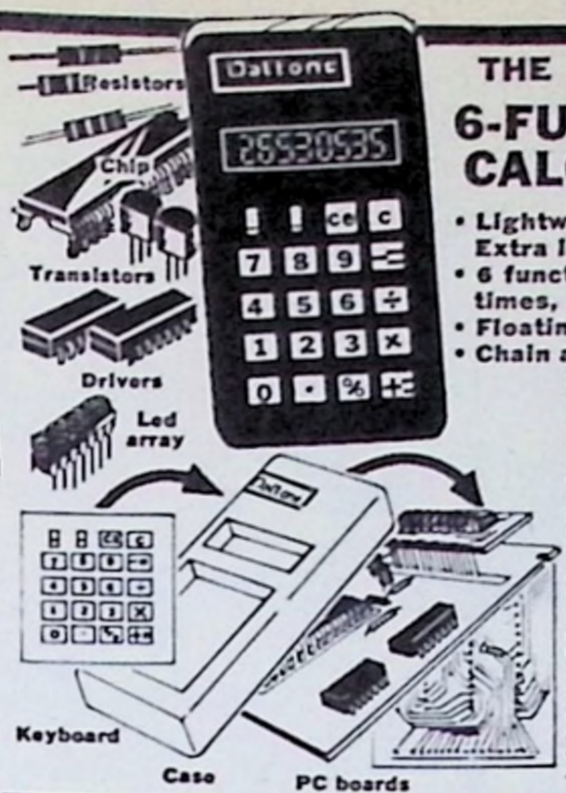

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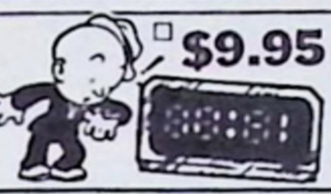

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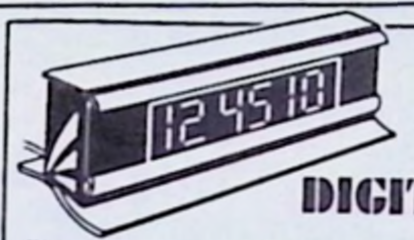

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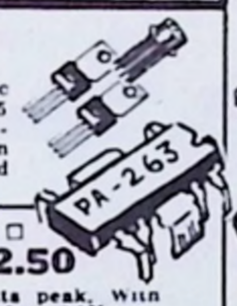

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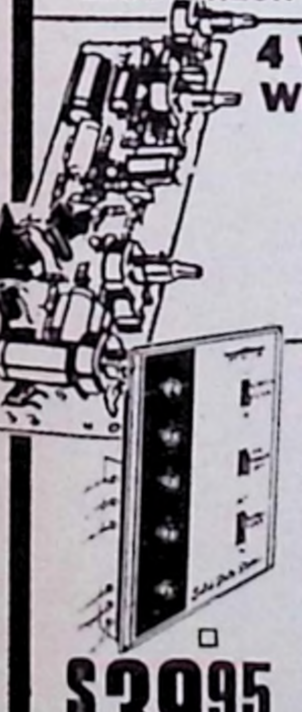

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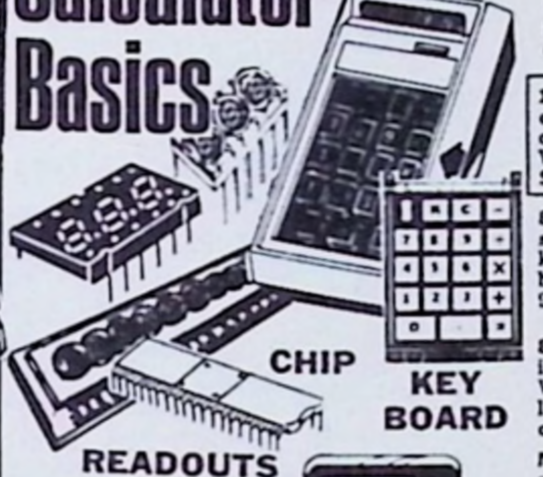

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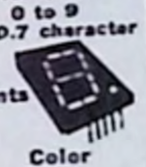

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☐ SN7427	.35
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☐ SN7443	1.00
☐ SN7444	1.00
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☐ SN7448	1.45
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☐ SN74155	1.29
☐ SN74156	1.45
☐ SN74157	1.45
☐ SN74158	1.45
☐ SN74160	1.85
☐ SN74161	1.59
☐ SN74163	1.75
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☐ SN74173	1.85
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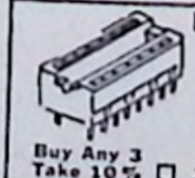

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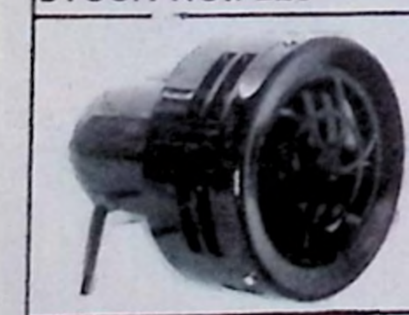

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C-MOS

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4004AE	5.90	5.90
4006AE	3.90	3.80
4007AE	.65	.60
4008AE	3.60	3.30
4009AE	.95	.94
4010AE	.95	.94
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4012AE	.54	.53
4013AE	1.15	1.05
4014AE	3.70	3.25
4015AE	3.80	3.70
4016AE	1.15	1.05
4017AE	2.90	2.70
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4019AE	1.30	1.20
4020AE	3.90	3.30
4021AE	3.80	3.60
4022AE	2.75	2.55
4023AE	.54	.53
4024AE	2.30	2.00
4025AE	.54	.50
4026AE	9.80	7.10
4027AE	1.35	1.22
4028AE	2.95	2.75
4029AE	5.40	4.60
4030AE	1.25	1.05
4035AE	2.85	2.80
4040AE	4.60	4.40
4041AE	3.30	3.20
4042AE	2.95	2.85
4043AE	2.95	2.85
4044AE	2.95	2.85
4047AE	3.70	3.60
4048AE	1.50	1.40
4049AE	1.35	1.05
4050AE	1.35	1.05
4056AE	3.50	3.46
4060AE	5.20	4.90
4066AE	3.20	2.96
4069AE	.85	.75

Schottky TTL

SN74S00N	$ .80
SN74S02N	.80
SN74S03N	.80
SN74S04N	.80
SN74S08N	.80
SN74S10N	.80
SN74S11N	.80
SN74S20N	.80
SN74S30N	.80
SN74S32N	.80
SN74S40N	.80
SN74S41N	.80
SN74S64N	.80
SN74S74N	1.50
SN74S85N	6.10
SN74S86N	2.90
SN74S112N	2.50
SN74S113N	1.50
SN74S133N	1.00
SN74S138N	4.50
SN74S139N	3.90
SN74S140N	1.00
SN74S151N	3.30
SN74S153N	3.30
SN74S154N	3.40
SN74S157N	2.70
SN74S158N	3.00
SN74S160N	6.60
SN74S161N	6.60
SN74S174N	4.75
SN74S175N	4.00
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SN74S194N	3.30
SN74S195N	4.40
SN74S251N	4.20
SN74S253N	4.20
SN74S275N	3.20
SN74S258N	3.70
SN74S260N	.90
SN74S280N	5.70
SN74289N	5.00
93S10	6.80
93S16	6.80
93S21	3.50
93S22	3.20
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XR205K Only $28.00

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LM352: 6-15V, 1.15W, 8Ω	1.60
LM354A: 6-27V, 2.80W, 8Ω	2.50
TAA611B12: 6-15V, 1.15W, 8Ω	1.60
TAA621A12: 6-27V, 1.40W, 8Ω	2.00
TBA641B11: 6-18V, 2.20W, 4Ω	3.00
TBA800: 5-30V, 4.70W, 8Ω	2.20
TBA810AS: 4-20V, 2.50W, 4Ω	3.00
TBA820: 3-16V, 0.75W, 4Ω	1.70
TCA830: 5-20V, 2.00W, 4Ω	2.20
TCA940: 6-24V, 6.50W, 8Ω	4.40

DUAL LOW NOISE OP AMP

LM331N:
V_{io} = 6mV
I_{ie} = 1000nA
I_b = 2000nA
Noise = 1.5dB
$2.20

Calculator

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SI-1010G	10W	$ 6.90
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P3101A	5.50
MM6560N	5.00
MM6561N	5.00
DM8599N	5.00
93403	5.00

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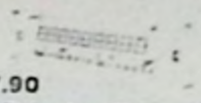
P1103 $6.20



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9-Digit Display

- 1/8" character height
- compact, thin PC package
- wide viewing angle

Displays

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SLA4	Red	7.50
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Optoisolator

MCT2 1.45

MV50 Red $ .30

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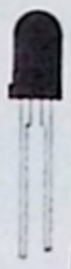
.125"dia.

209	Red	$ .25
209	Yellow	.35
209	Green	.35

.160"dia.

216	Red	.25
216	Yellow	.30
216	Green	.30



.200"dia.

220	Red	.25
220	Yellow	.30
220	Green	.30

LOW PROFILE

226	Red	$ .25
226	Yellow	.30
226	Green	.30
226	Orange	.30

5053	Red	$ .35
5053	Yellow	.40
5053	Green	.40
5053	Orange	.40

216 = MV5024
5053 = MV5053

Power Transistors

BU204	3A	1300V	$4.14
BU205	3A	1500V	4.95
BU206	3A	1700V	5.94
BU207	6A	1300V	5.85
BU208	6A	1500V	6.93
BU209	6A	1700V	8.64

2N5128	$3.00
2N1136	1.50
2N1483	1.20
2N1534	1.00
2N1540	1.10
2N1544	.90
2N3053	.35
2N3055	.95
2N3375	5.50
2N3442	2.20
2N3730	1.70
2N3731	2.00
2N3732	1.50
2N3771	2.20
2N3772	2.30
2N3773	3.40
2N3789	3.00
2N3866	.95
2N4347	1.60
2N4348	2.00
2N4395	1.30
2N4427	1.10
2N5109	2.10
2N5322	.92
2N5323	.70
2N6099	.80
2N6101	.80
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36 pin DIL	1.70
40 pin DIL	1.90

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4 pin	TO-5	.65
6 pin	TO-5	.90
8 pin	TO-5	1.10
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LM204H	4.70
LM205H	3.00
LM209H	3.50
LM209K	3.70
LM300H	.90
LM300N	1.40
LM304H	1.40
LM305H	1.10
LM305AH	1.40
LM305N	1.20
LM309H	1.75
LM309K	1.95
LM340-05K	2.60
LM340-06K	2.60
LM340-08K	2.60
LM340-12K	2.60
LM340-15K	2.60
LM340-18K	2.60
LM340-24K	2.60
LM723H	1.30
LM723D	3.90
LM723CH	.80
LM723CN	.75
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L130	1.50
L131	1.50
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LM302H	TO-5	.95
LM302N	Dip	1.40
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LM307H	TO-5	.90
LM307M	Mini-dip	.90
LM308H	TO-5	1.20
LM308AH	TO-5	5.00
LM310H	TO-5	1.40
LM311H	TO-5	1.70
LM318H	TO-5	2.50
LM555CM	Mini-dip	.90
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LM709CN	Dip	.45
LM710CH	TO-5	.60
LM710CN	Dip	.75
LM715CH	TO-5	4.30
LM725CH	TO-5	5.00
LM733CH	TO-5	1.50
LM733CN	Dip	1.50
LM741CH	TO-5	.45
LM741CM	Mini-dip	.44
LM747CH	TO-5	1.90
LM747CN	Dip	.90
LM748CN	Dip	.40
LM3046CN	Dip	.95
LM3054CN	Dip	1.50

Phase Locked Loops

LM567CM Mini-dip 2.10

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LM336K: 12V, 500mA	2.90
LM337K: 15V, 450mA	2.90

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7400N	$ .16			74150N	$ 1.14
7401N	.23			74151N	.75
7402N	.22	7474N	.38	74152N	2.25
7403N	.22	7475N	$ .68	74153N	1.12
7404N	.25	7476N	.59	74154N	1.63
7405N	.29	7480N	.66	74155N	1.49
7406N	.38	7481N	1.21	74156N	1.49
7407N	.48	7482N	1.01	74157N	1.19
7408N	.24	7483N	1.01	74158N	1.54
7409N	.54	7484N	3.01	74160N	1.50
7410N	.24	7485N	2.49	74161N	1.35
7411N	.29	7486N	.49	74162N	1.50
7412N	.51	7489N	2.99	74163N	1.50
7413N	.78	7490N	.75	74164N	1.89
7414N	2.81	7491N	1.40	74165N	1.89
7416N	.46	7492N	.84	74166N	1.98
7417N	.64	7493N	.84	74170N	2.55
7420N	.19	7494N	1.29	74173N	1.79
7421N	.51	7495N	.88	74174N	1.52
7423N	.49	7496N	.88	74175N	1.50
7425N	.39	7497N	2.50	74176N	1.69
7426N	.29	74100N	1.45	74177N	1.69
7427N	.35	74105N	.54	74180N	2.49
7428N	.51	74107N	.48	74181N	3.85
7430N	.22	74108N	.91	74182N	1.19
7432N	.28	74109N	.91	74184N	2.89
7433N	.61	74110N	.71	74185N	2.29
7437N	.44	74111N	.91	74190N	2.89
7438N	.44	74114N	.91	74191N	2.89
7439N	1.01	74115N	.91	74192N	1.49
7440N	.19	74118N	1.50	74193N	1.39
7441AN	1.16	74119N	.81	74194N	1.35
7442N	.98	74121N	.54	74195N	.99
7445N	.98	74122N	.89	74196N	2.39
7447N	1.50	74123N	.95	74197N	2.39
7448N	1.29	74125N	1.39	74198N	2.59
7450N	.23	74126N	1.39	74199N	4.48
7451N	.28	74128N	1.21	74200N	5.05
7453N	.25	74132N	2.05	74122N	1.75
7454N	.26	74136N	.91	74251N	1.75
7460N	.24	74141N	1.89	74278N	2.95
7470N	.30	74145N	1.79	74293N	.92
7472N	.39	74147N	2.95	74293N	.92
7473N	.46	74148N	3.55	74298N	2.55

LOW POWER TTL

74L00N	$ .34
74L02N	.34
74L03N	.39
74L04N	.39
74L10N	.34
74L20N	.39
74L42N	1.62
74L47N	2.60
74L51N	.34
74L73N	.74
74L74N	.89
74L90N	1.62
74L93N	1.74
74L95N	1.62

93L00	1.50
93L01	1.60
93L08	3.20
93L09	1.80
93L10	2.80
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93L12	1.80
93L14	1.70
93L16	3.20
93L18	3.50
93L21	1.50
93L22	1.80
93L24	2.80
93L28	3.70
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DM8832N	5.00
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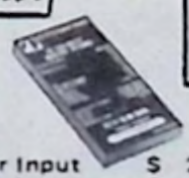

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CY1011A	Instr. Amp., Bipolar Input	49.00
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2533V	10.90
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74H05N	.38
74H08N	.44
74H10N	.44
74H11N	.44
74H15N	.38
74H20N	.39
74H40N	.36
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	10	100	1000
1N4001	$ 1.00	7.00	60.00
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1N4004	1.30	10.00	90.00
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10 UFD/16V	14c	12c	11c
10 UFD/25V	14c	12c	11c
22 UFD/16V	14c	12c	11c
22 UFD/25V	15c	13c	12c
33 UFD/16V	15c	12c	11c
33 UFD/25V	17c	13c	12c
47 UFD/16V	17c	14c	13c
47 UFD/25V	19c	15c	14c
100 UFD/16V	19c	15c	14c
100 UFD/25V	24c	18c	17c
220 UFD/16V	24c	18c	17c
220 UFD/25V	35c	25c	24c
330 UFD/16V	35c	25c	24c
330 UFD/25V	44c	35c	32c
470 UFD/16V	37c	30c	27c
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.047. . .	9c	6c	5.3c	4.25c
.1.	12c	9c	7.5c	6c

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2N3391A	. TO- 98	22c	19.0c	17.5c
2N3392	. . TO- 98	22c	19.0c	17.5c
2N3393	. . TO- 98	22c	19.0c	17.5c
2N3394	. . TO- 98	22c	19.0c	17.5c
2N3563	. . TO-106	20c	17.5c	17.5c
2N3565	. . TO-106	20c	17.5c	16.0c
2N3638	. . TO-105	20c	17.5c	16.0c
2N3638A	. TO-105	20c	17.5c	16.0c
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2N4126	. . TO- 92	22c	19.0c	17.5c
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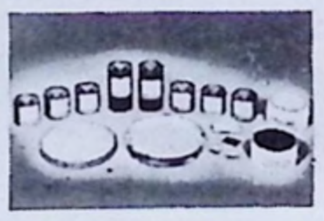

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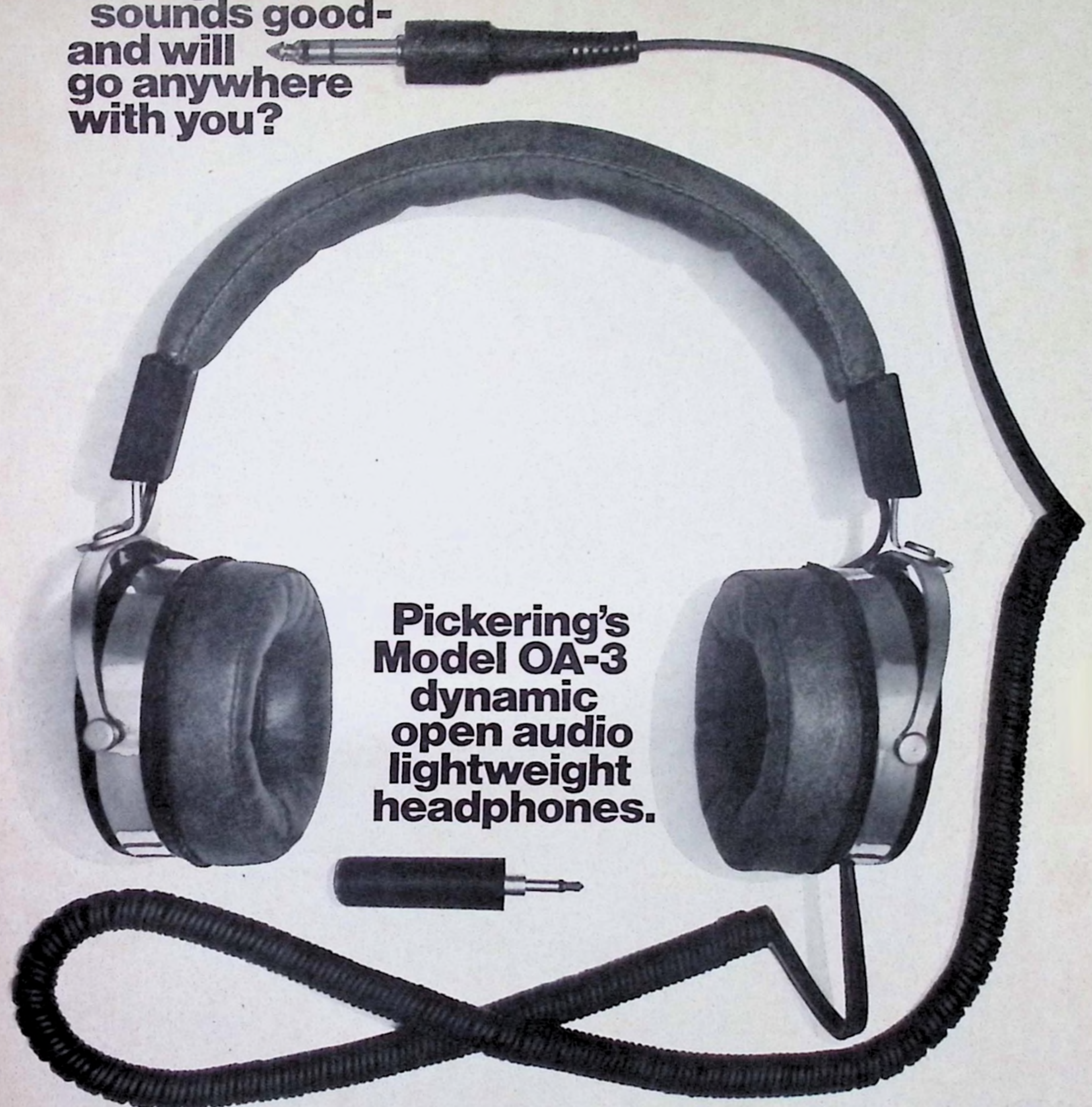

Pickering's Model OA-3 dynamic open audio lightweight headphones.

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CIRCLE NO. 29 ON READER SERVICE CARD

The Dual 1229Q. Why many music lovers will settle for nothing less.

united audio

Many serious music lovers are not satisfied unless every component in their system is the very finest in its class, with cost secondary. The 1229Q, Dual's highest-priced multi-play turntable, is one of these "no compromise" components.

The 1229Q is a full-sized turntable with a twelve-inch dynamically balanced platter that weighs a full seven pounds. Its massive platter is driven by Dual's powerful Continuous-Pole/synchronous motor.

The 8-3/4" tonearm is mounted in a true gyroscopic gimbal that centers and balances it within both axes of movement. All four tonearm pivots turn on identical low-friction bearings permitting flawless tracking at as low as 0.25 gram. And since a turntable of the 1229Q's calibre is used most frequently in the single-play mode, the tonearm is designed to track at precisely the correct angle in that mode. With the exclusive Mode Selector, tracking angle can be instantly adjusted for correct tracking at mid stack in the multi-play mode.

Low capacitance tonearm leads and an anti-skating system with separate calibrations for conical, elliptical and CD-4 styli, make the 1229Q compatible with any stereo and four-channel cartridge available or likely to be available in the foreseeable future. Other features include a calibrated illuminated strobe with adjustable viewing angle, and cueing damped up as well as down to prevent bounce.

The 1229Q is too new for test reports to have appeared, but reports on its immediate predecessor, the Dual 1229, indicate why it was the largest selling quality turntable ever made. Stereo Review called its rumble measurements "among the best we have yet made on a turntable." High Fidelity said, "It takes one step further the progressive improvements that have made top Dual models among the most popular turntables in component systems for the better part of a decade, to judge by readers' letters."

Stereo & HiFi Times' noted, "I unhesitatingly recommend it to anyone looking for the best possible record playing equipment." And Popular Electronics rated it "the equal of any combination of record playing components known to us."

Of course, not everyone can afford the 1229Q's price: $259.95. But every Dual turntable, starting with the 1225 at $129.95, provides the same high quality materials, carefully finished parts and meticulous quality control that have long earned Dual its reputation for reliability.

Thus which Dual you select is not terribly important. Your choice can be made in terms of the level of refinement you require. And if, like many music lovers, you require every refinement it is possible to have in a multi-play turntable, chances are you too will choose the Dual 1229Q.

Dual **United Audio Products**
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CIRCLE NO. 4 ON READER SERVICE CARD